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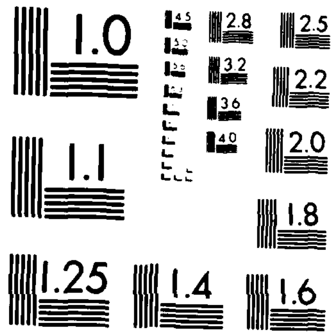

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Research Note 84-136

AD-A148 642

INTERIM REPORT FOR MANPOWER AND PERSONNEL REQUIREMENTS DETERMINATION METHODOLOGIES (MANPERS)

C. Mazie Knerr, Elmo E. Miller, Lawrence B. Nadler
and Susan K. Dowell
Human Resources Research Organization

Francis O. Deppner, Gene P. Hill and Richard L. Somers
General Research Corporation

Bruce W. Knerr, Contracting Officer's Representative

Submitted by

Bruce W. Knerr, Acting Chief
SYSTEMS MANNING TECHNICAL AREA

and

Jerrold M. Levine, Director
SYSTEMS RESEARCH LABORATORY

U. S. Army

Research Institute for the Behavioral and Social Sciences

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This is an interim report of Manpower and Personnel Requirements Determination Methodologies (MANPERS), Phase I of a three-phase project entitled "Development of the Army Manpower and Personnel Requirements Process (ARMPREP)." This report covers initial research into manpower and personnel requirements determination processes utilized by other services. It also covers information gleaned from the subject matter experts who are employed by the Army Materiel and Combat Developer. Included in the report is a statement of requirements for developing an ideal baseline to generate Army manpower and personnel requirements. (Cont)

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Human Resources Research Organization
300 North Washington Street
Alexandria, VA 22314

Block 10
5001 Eisenhower Avenue
Alexandria, VA 22333

Block 19
analysis, life cycle system management model.

Block 20
To support the requirements determination process, an MOS and related task oriented taxonomy, ~~has been~~ developed along with algorithms and procedures for use in developing the qualitative and quantitative personnel requirements information associated with new weapon systems development. Originator-supplied [illegible] block 19)

BRIEF

Objective:

The overall ARMPREP objective is to develop procedural and systems tools to aid and improve the determination of manpower and personnel requirements for new Army systems. The first four tasks of Phase I are addressed in this interim report. These tasks call for establishment of an "ideal baseline" for requirements development, design of a taxonomy to support requirements determination, and development of algorithms and procedures for implementation of the recommended methodologies.

Procedures:

Four major tasks have been addressed during this period of research. Task 1, Establishment of the Requirement for Manpower and Personnel Requirements Determination Methodologies (MANPERS), has involved assessing the state-of-the-art in manpower and personnel requirements determination for new systems through documentation review and interview of subject matter experts. The type, quality, and flow of data input to the process have been assessed and an "ideal baseline" for requirements development has been postulated.

Task 2 required the development of a taxonomy for derivation of behavioral requirements from new system task descriptive data. Existing taxonomies were reviewed and two new taxonomies to aid in MOS determination were developed.

Tasks 3 and 4 require the development of algorithms and procedures for implementation of new methodologies. This work is still in process.

Findings:

Current processes for documenting manpower and personnel requirements are complex, incompletely understood, and imperfectly executed; as a result, systems are being deployed with inadequate manpower. The "ideal baseline" addressed in this report offers prescriptive solutions to many of these problems and is attainable within the state-of-the-art. The taxonomic procedures considered in this baseline offer the potential for increased rigor and standardization in new system MOS determination.

Utilization of Findings:

Research results to date should be used as a basis for continuing development, demonstration, and evaluation of supporting methods and procedures. The two major foci of this effort should be continued development of procedures and tools to aid in MOS definition and quantification, and the definition of specific procedures required to implement other "ideal baseline" systems and procedural improvements.

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FIGURES (Continued)

INTRODUCTION

This interim report addresses the initial 6 months of research directed toward development of the Army Manpower and Personnel Requirements Process (ARMPREP). Covering accomplishments to date on Tasks 1 through 4 of the first phase, it details methods and results (procedures and findings), suggests conclusions, and makes recommendations as to utilization of findings in continuing research to meet project objectives. The introduction offers an overview of the ARMPREP project, as well as highlighting major elements of the report which follows. Subsequent sections treat individual tasks, conclusions, and recommendations.

THE ARMPREP PROJECT

Other materials developed by the US Army Research Institute (ARI) provide comprehensive details on the background, technical objectives, and scope of ARMPREP research. This overview is provided as a convenience for relating the details which follow to the long-term direction of the effort.

The ARMPREP project is part of an overall ARI thrust in the area of systems manning technology. It is an element of the Man Integrated System Technology (MIST) effort and is focused on the development of procedural and systems tools to aid and improve the manpower and personnel requirements determination processes associated with the acquisition of new Army systems. Specific problems which ARMPREP research is seeking to solve include:

- A lack of formal (standarized and replicable) methods for determining manpower and personnel requirements for specific systems tailored to each stage of the Life Cycle System Management Model (LCSMM).
- A lack of procedures and techniques (tools) for aggregating new system requirements to facilitate demand versus supply and affordability determinations.

- Limited accountability and management capability for the development and processing of new system manpower and personnel requirements information.
- The lack of adequate automated systems to support information storage, retrieval, computational, and management aspects of the process.

To address these problems, ARMPREP research is divided into three phases and four major components:

- Phase I - Manpower and Personnel Requirements Determination Methodologies (MANPERS)
- Phase II
  - Manpower Demand Aggregation Procedures (TOTAL MANPERS)
  - Requirements for a Manpower Requirements Management Information System (MARMIS)
- Phase III - A computer interactive system for determination of manpower and personnel requirements (AUTO MANPERS)

PHASE I - MANPERS

The MANPERS component is focusing on the development of tools and techniques to assist individuals responsible for determining new system manpower and personnel requirements. Increased rigor and standardization, and development of better estimates earlier in the LCSMM are major goals. The first four tasks, which are the subject of this interim report, involve:

- Establishment of requirements for MANPERS.
- Development of a taxonomy for the derivation of behavioral requirements from new system task descriptive data (TDD).
- Development of an algorithm for the translation of behavioral requirements into military occupational specialty (MOS) and other related relationships.

- Development of procedures for implementing the MANPERS methodologies.

The first two tasks have been completed, although findings, conclusions, and recommendations are expected to be augmented and modified as research progresses. Tasks 3 and 4 are in process; while some significant opportunities for improved tools and processes supportive of project goals have been identified, it is clear from initial research that additional development and evaluation will be essential.

Remaining Phase I tasks involve test and application of methods and procedures currently under development. Specific tasks call for:

- Development of job aids and examples of manpower and personnel requirements determination processes using MANPERS methodologies.
- Demonstration and evaluation of MANPERS products.
- Development of a MANPERS Manual.
- Conduct of user community reviews.
- Technical report preparation.

REMAINING PHASES/COMPONENTS

TOTAL MANPERS

The TOTAL MANPERS component is intended as an expansion of MANPERS methodologies to provide for extension and aggregation of new system manpower and personnel data within and across systems. Its objective is to provide an orderly and systematic basis for affordability determination and comparison with supply at strategic points in the LCSMM and Planning, Programming, Budgeting, and Execution System (PPBES) so that this information can be used in support of critical design and development decisions.

MARMIS

The focus of MARMIS is on controlling new system manpower and personnel requirements information and improving the availability of associated documentation. Manual and automated procedures and their interfaces are to be explored, system requirements identified, and a model developed.

AUTO MANPERS

The culmination of the ARMPREP project will be the development of an implementation and test plan for previous ARMPREP technical products to include requirements and specifications for a computer interactive system (AUTO MANPERS) to integrate and support essential processes and a projective test of ARMPREP technical products. Additional product refinements and implementability will be a key focus of this phase.

REPORT HIGHLIGHTS

Task 1 - MANPERS Requirements

Manpower requirements determination processes of the Army and other services were reviewed. The Navy HARDMAN process is described in Appendix A, while the Air Force processes are described in Appendix B. Select groups of subject matter experts (SME) were interviewed. These SME represented the Materiel and Combat Developers and the Trainer. In addition, Army policy and procedural guidance literature was reviewed. Based upon the SME interviews and literature review, an "ideal baseline" for manpower and personnel requirements determination was formulated. Baseline requirements are oriented to the LCSMM and identify a need for systematic documentation and preservation of information which should be developed during analyses conducted to secure project approval and for subsequent milestone reviews. There are adequate opportunities during the system development life cycle to significantly improve the timeliness and quality of manpower and personnel requirements for new systems. Recommended improvements are considered feasible within the current state-of-the-art.

Task 2 - Taxonomic Development

Development of a taxonomy for the derivation of behavioral requirements from new system TDD draws from Task 1 input. Task 1 identified important documents [e.g., Quantitative and Qualitative Personnel Requirement Information (QQPRI) and Basis of Issue Plan (BOIP)] and processes (e.g., LCSMM) related to manpower and personnel requirements determination and addressed the information which is required at various developmental phases for determining the manning of a new or improved Army system. This information, when placed in the context of an organized framework, constitutes the basis for the ARMPREP taxonomic system.

In developing the taxonomy for deriving behavioral requirements from new weapon system TDD, existing behavioral taxonomies were reviewed and assessed in terms of their utility for manpower and personnel requirements determination. The application of specific, formal criteria for the ARMPREP taxonomy led to the determination that existing taxonomies were not directly applicable. Army documents (e.g., AR 611-201), however, contain relevant information which has been adapted to accomplish the Task 2 objectives by developing two taxonomies, one for determining the MOS for a new system based upon equipment, and the other to aid in formulating task dimensions. The model encompasses the type and level of data required at each phase of the LCSMM.

Tasks 3 and 4 - Algorithms and Procedures

Task 3 is concerned with developing algorithms for translating behavioral requirements into MOS and other related relationships by applying the taxonomic system. A general description of this translation process, using taxonomic elements to make MOS determinations, is provided. The algorithms, which are structured to an Army context, are also linked, in terms of the quantity and quality of the data output provided, to the phases of the LCSMM.

After generating the algorithms, the procedures for using them, as well as the behavioral requirements and the taxonomic model, are described in Task 4. In the ensuing months, work on the Task 3 and 4 products will be oriented toward expanding the algorithms and procedures which will be compiled, with illustrations, into the MANPERS user's manual. Procedures to be developed will also encompass other systems and procedural requirements addressed in the "ideal baseline."

CONCLUSIONS

The process of documenting the manpower and personnel requirements associated with new systems is complex; it involves many geographically dispersed organizations and its details are not consistent nor consistently understood among participants. Essential information is being lost because there is no systematic recording capability. Systems and procedures improvements to deal with these and related problems are feasible. In addition, objectivity in MOS determination can potentially be improved through application of the taxonomic structures addressed in this report, but additional research in this area is still required.

RECOMMENDATIONS

The remaining Phase I tasks, involving the demonstration and evaluation of methods and procedures currently being developed and preparation of a MANPERS manual, should continue. This effort would have two major foci:

- Development of procedures and tools to aid in MOS definition and quantification at each LCSMM stage.
- Definition of specific procedures required to implement other systems and procedural improvements incorporated in the "ideal baseline."

ESTABLISH THE REQUIREMENTS FOR MANPOWER AND PERSONNEL REQUIREMENTS DETERMINATION METHODOLOGIES (MANPERS)

BACKGROUND

In order to establish the MANPERS component of ARMPREP, it is first necessary to formulate requirements for techniques and methodologies to improve estimation of Army manpower and personnel for new systems. These MANPERS requirements are intended to be the basis for standardizing manpower and personnel definition within the context of the Army programs for force modernization or product improvement. The following portions of this section address the current process, problems, the ideal MANPERS baseline, and areas for improvement.

Objectives

The objectives as listed in the contract statement of work are to:

- Perform an assessment of the state-of-the-art in methodologies for determining manpower and personnel requirements to field new systems.
- Review current documentation on the Army's manpower and personnel requirements determination process.
- Determine the type and quality of data input to the manpower and personnel requirements determination process.
- Review Air Force and Navy documentation relative to the manpower and personnel requirements determination process.
- Interview select groups of SME to include Army materiel and combat developers as well as behavioral scientists familiar with the personnel requirements issues.
- Determine the requirements for MANPERS in the manpower and personnel requirements determination process.
- Describe the Army "ideal" baseline for manpower and personnel requirements development (specifically QQPRI) according to SME interviews, Army regulations, and other relevant documentation.

- Specify the degree to which this "ideal" baseline is or is not achievable, given the current state-of-the-art.

Data Collection

This report synthesizes information collected from a review of literature, interviews conducted in the Washington area with staff members of Headquarters, Department of the Army (HQDA), Headquarters, US Army Materiel and Readiness Command (HQ DARCOM), and US Army Soldier Support Center-National Capital Region (SSC-NCR), and interviews conducted at DARCOM and US Army Training and Doctrine Command (TRADOC) field agencies.

An extensive literature review was conducted during this period. To preclude duplication of the "Materiel Modernization Reference Compendium" being prepared by the MIST contractor, the references listed here are those that support a particular point. Synopses of other service manpower and personnel requirements determination procedures or processes are attached as Appendices A and B. Although review of Navy and Air Force approaches to this problem was useful, no specific procedures or models were considered directly adaptable for ARMPREP application.

The objective of the field interviews was to learn the current approaches and problems from the principal DARCOM and TRADOC agencies that contribute to the QQPRI and BOIP development process. The schedule of visits is in Appendix C.

Of particular importance to this project are the results of several current and relevant studies:

- HQDA Inspector General examination of the force modernization issues, procedures, and processes (classified For Official Use Only).
- Man-Machine Interface Study of TRADOC and DARCOM.
- The Coventry Report, developed by a staff officer of the Army Force Modernization Coordinating Office (AFMCO).

CURRENT BOIP PROCESS

Definition of Terms

A glossary is provided in Appendix D; however, several terms are defined below to reduce the chance of misunderstanding. These essential terms are:

- Materiel Developer - The command or agency responsible for research, development, and production validation of a system which responds to HQDA approved materiel requirements. DARCOM is the principal materiel developer and is so depicted in supporting figures and tables.
- Combat Developer - The command or agency responsible for doctrine, concepts, requirements, and organizations. TRADOC is the principal combat developer and is so depicted in supporting tables and figures.
- Basis of Issue Plan Feeder Data (BOIPFD) - The submission of the materiel developer which describes the modernization equipment.
- Qualitative and Quantitative Personnel Requirements Information (QQPRI) - The materiel developer submission which provides information about the personnel required to operate, maintain, and repair one set or piece of equipment under development.
- Basis of Issue Plan (BOIP) - The combat developer uses the BOIPFD and QQPRI as references in conjunction with the organizational and operational doctrine to develop another document called the BOIP. The completed BOIP contains equipment and personnel changes required to integrate the modernization system into existing organizational requirements documents [i.e., Tables of Organization and Equipment (TOE)].
- Automated Unit Reference Sheet (AURS) - The AURS is a precursor to a draft TOE. It is the combat developer's expansion of the BOIPFD and QQPRI into a complete BOIP

equipment and personnel requirement. It is used to establish a new organization when an existing TOE is not acceptable for new equipment and concepts. The combat developer is responsible for the AURS and it includes the total organizational needs identified by the BOIPFD and QQPRI for all equipment and personnel necessary to operate and support the modernization system in a new organizational structure. The AURS has the format of and is used as a Table of Organization and Equipment (TOE) (e.g., the PATRIOT air defense system required an AURS). (Note: Either a BOIP or AURS is used to implement the developmental item into the force structure but generally never both.)

LCSMM and QQPRI-Related Input

Despite the many events in the Life Cycle System Management Model (LCSMM) chart in DA Pamphlet 11-25 which depict manpower data, there are only two mandatory QQPRI submissions; the processing of either submission may contribute to losing information that will otherwise influence the MOS decision:

- Tentative QQPRI (TQQPRI) must be sent to TRADOC through the US Army Materiel Readiness Support Activity (MRSA) not later than (NLT) 9 months before the completion of Milestone II.
- The Final QQPRI (FQQPRI) must be sent to TRADOC through MRSA NLT 33 months prior to the equipment availability date or 21 months prior to the estimated type-classification (TC) date, whichever occurs first.

It is permissible to submit amendments to either TQQPRI or FQQPRI at any time prior to the TC date. The use of such amendments was found to be relatively limited (Deppner et al., 1980, Report on Input Data Quantity), due largely to the cumbersome nature of document preparation and processing flows.

QQPRI Flow

Overview

The three principal organizations responsible for the research, development, and deployment policy of a system under development are: (1) DARCOM - the materiel developer, (2) TRADOC - the training and doctrine (i.e., combat) developer, and (3) HQDA - the force modernization planner.

Figure 2.1 depicts the essential elements of the roles played by the three organizations. An explanation of the figure follows.

- Zone of Responsibility - This part of the matrix is intended to emphasize the limits or boundaries of information appropriate for each organization, e.g.:
  - DARCOM is only responsible for describing the attributes and resource requirements of the system under development. In this respect, the QQPRI represents requirements for operating, maintaining, and supporting one new system only, even though two or more identical new systems may be implemented in a unit. For example, the QQPRI for a tank would state requirements to operate, maintain, or support one tank; whereas a tank battalion may be equipped with 54 tanks.
  - TRADOC is responsible for expanding on the DARCOM data and describing the resource requirements of system-using and system-supporting organizations. TRADOC utilizes the BOIPFD to ensure component items and associated items of equipment (ASIOE) are included and considered in developing the BOIP.
  - HQDA is responsible for expanding on the TRADOC data and evaluating the impact of the modernization system upon the total force structure.

AN OVERVIEW OF THE QQPRI-BOIP PROCESS
THE PRINCIPAL ORGANIZATIONAL PLAYERS

DARCOM	TRADOC	HQDA
V	V	V

ANALYZE THE INPUT

DEVELOP THE FOLLOWING:

	V	V	V
ZONE OF RESPONSIBILITY:	ONE SYSTEM	SYSTEMS IN UNITS + SUPPORTING UNITS	SYSTEMS IN THE TOTAL FORCE
DATA DEVELOPED:	BOIPFD (equip) QQPRI (manpower)	BOIP - equip - manpower Requirements document Equip/manpower impact report	Procurement and distribution planning (units to be equipped)
CONCEPTS DEVELOPED:	Maintenance	Organizational & Operational	
MOS ACTION:	Recommendation	Recommendation	Decision
SYSTEM IMPACT ANALYSES PERFORMED:		Training Feasibility (rotation base, career path, SGA) Supportability (faces - aptitudes)	Affordability (spaces, force structure)
	V	V	V
	Forward to TRADOC	Forward to HQDA	Return to TRADOC

Figure 2.1. An Overview of the QQPRI-BOIP Process

- Data Developed
  - DARCOM describes the single system requirements in BOIPFD and QQPRI.
  - TRADOC develops the BOIP (or AURS) to indicate new or changes in organizational requirements. Then TRADOC computes the total system equipment and personnel requirement impacts on current TOE.
  - HQDA uses the BOIP (or AURS) in the Logistics Structure and Composition System (LOGSACS) to compute the Army Acquisition Objective (AAO) and the Total Army Equipment Distribution Program (TAEDP). BOIP (or AURS) are also applied in the Personnel Structure and Composition System (PERSACS) to identify the impact of new systems on personnel requirements by unit, grade, and MOS.
- Concepts Developed
  - DARCOM develops the maintenance concept which describes the level of maintenance to which the system is designed. For example, if maintenance is performed in the Army vs. contract, different considerations such as training, parts stockage, and level of maintenance are involved. The level of maintenance may be organizational, direct support (DS), general support (GS), and depot or different considerations of these levels combined with contract maintenance.
  - TRADOC develops the detailed organizational and operational concept which describes the employment and support of the new system.
- MOS Action
  - DARCOM recommends the MOS appropriate to operate, maintain, and repair the new system.
  - TRADOC (SSC-NCR) makes the final MOS recommendations.
  - HQDA (ODCSPER) makes the MOS decision.

- System Impact Analyses Performed
  - TRADOC (training developer) estimates the training impact of the new system.
  - TRADOC (SSC-NCR) estimates the feasibility and supportability of the new system.
  - HQDA (ODCSPER) estimates the personnel affordability of the new system.

Agency-Level Actions

DARCOM. The three principal players in the DARCOM community (see Figure 2.2) are: (1) the Materiel Development Commands and Materiel Readiness Commands (MDC/MRC), (2) the Equipment Authorization Review Agency (EARA), and (3) the MRSA.

If the system under development meets specified dollar thresholds, it will be managed by a project manager (PM), while the remainder are under MDC management. The specific MDC/MRC actions are shown in Figure 2.3.

The Logistics Analyst or Materiel Systems Coordinator at the MDC/MRC is responsible for pulling together the information to prepare the BOIPFD and take the following actions:

- From the design engineer:
  - Obtain the system hardware description and primary usage, to include:
    - Developmental items.
    - End-items used as components. The components are end-items integral to the item under development, e.g., radios, air conditioners, and the five-ton truck chassis.

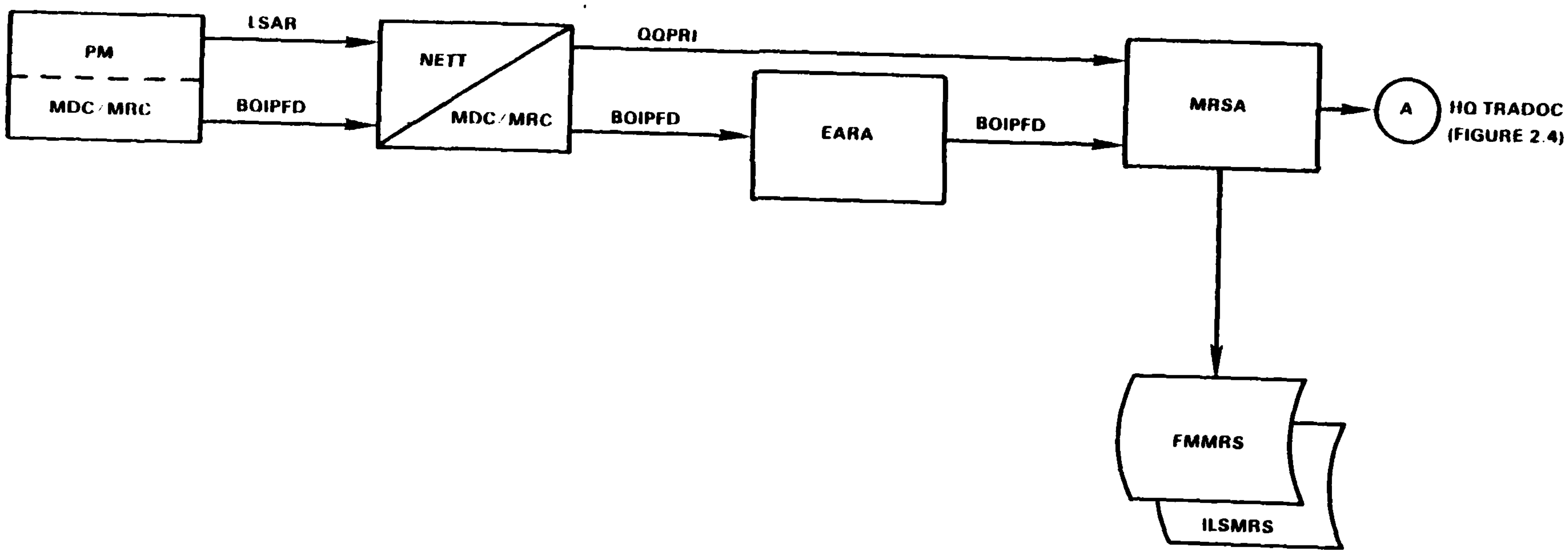

Figure 2.2. The Principal Materiel Developer Players

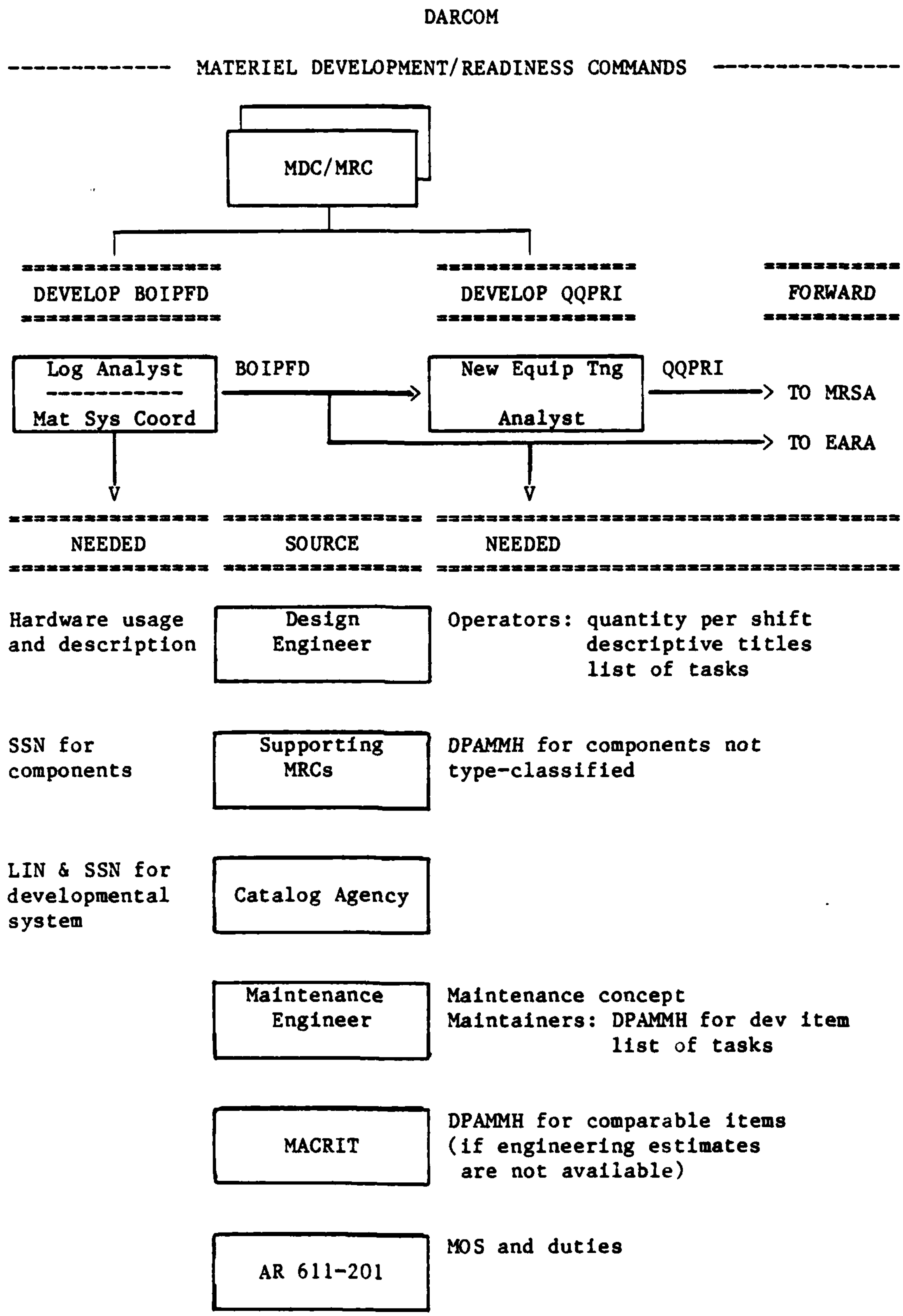

Figure 2.3. The Principal Actions at Materiel Development and Readiness Commands

-- Associated support items of equipment (ASIOE). The ASIOE are external end-items required to make the set operate, e.g., portable AC generators.

-- Test, measurement, and diagnostic equipment (TMDE).

Note: One of the primary contributors to <u>understated equipment requirements</u> (which in turn understates funds and maintenance man hours) is the lack of component and ASIOE information.

- From supporting MDC/MRC:
  - Obtain the SSN for components to be used within the developmental item(s) assemblage.
- From the Comptroller, MDC/MRC:
  - Obtain a line item number (LIN) which will identify the system in Supply Bulletin (SB) 700-20.
  - Obtain a standard study number (SSN) which provides a mechanism for computing an AAO for Procurement Appropriations (PA).
- Forward BOIPFD:
  - Forward the completed BOIPFD to the new equipment training (NET) team and to EARA.

The NET analyst is responsible for preparing the QQPRI based on information contained in the BOIPFD and takes the following actions:

- From the Design Engineer:
  - Obtain information about the system direct operators:
    - -- Quantity per single shift
    - -- Descriptive titles
    - -- List of tasks
- From supporting MRCs:
  - Obtain DPAMMH on components not type-classified.
- From the Maintenance Engineer:
  - Obtain the latest maintenance concept.

- Obtain information about the developmental item maintainers.
  -- DPAMMH at each maintenance level
  -- List of tasks
- From MACRIT:
  - Use comparable item DPAMMH if engineer estimates are not available.
- From AR 611-201:
  - Compare the system operator and maintainer tasks with those in AR 611-201 to select the most appropriate candidate MOSs.
- Forward QQPRI:
  - Forward the QQPRI to MRSA

The MDC/MRC is responsible for obtaining DPAMMH on all items of materiel for which they are proponents. These data are forwarded to MRSA for entry into the MACRIT data base.

EARA performs an equipment relationship analysis to determine if all of the components, ASIOE, and TMDC are (i.e., "seem to be") present and compatible. The BOIPFD is then forwarded to MRSA.

MRSA reviews the BOIPFD and QQPRI together for compatibility, completeness, and accuracy. When these criteria are met, MRSA forwards the two documents to HQ TRADOC.

TRADOC. Figure 2.4 indicates the potentially important players in the BOIP process. The term "potential" is used because some of the agencies shown are not in the document flow but do act on other force modernization issues.

The Deputy Chief of Staff for Combat Development (DCS-CD) has four directorates acting on force modernization issues, which are:

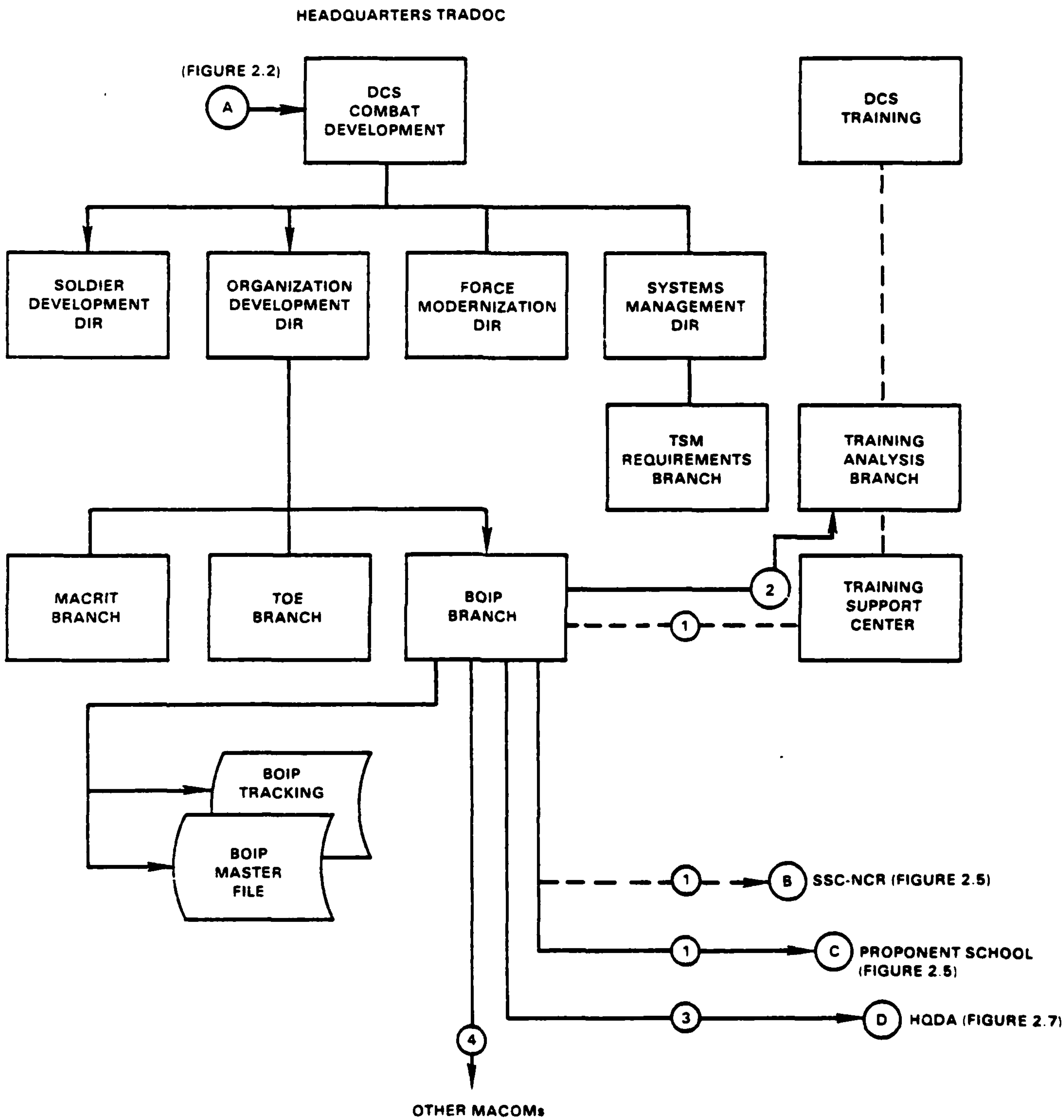

Figure 2.4. The Principal Combat Developer Players

- Force Modernization Directorate - Newly created and does not yet have a formal charter (according to telephonic interview).
- Soldier Development Directorate - The HQ TRADOC Point of Contact (POC) for all MOS recommendations, including those not related to materiel development.
- Organization Development Directorate - (To be discussed separately).
- Systems Management Directorate - The coordinator of the TRADOC System Manager (TSM), who is the TRADOC counterpart to the DARCOM PM.

The DCS for Training (i.e., Training Analysis Branch) reviews the BOIP package returned from the integrating centers for: (1) training impact and (2) the MOS recommendation.

The Training Support Center (at Fort Eustis, VA) reviews the BOIPFD and QQPRI for potential training device impact.

The Organization Development Directorate is responsible for the development of new TOE. Since the BOIP represents a planned change to existing TOE or the basis for a new TOE, this agency is the HQ TRADOC BOIP proponent.

The key player in this directorate for our purposes is the BOIP Branch, as Figure 2.4 shows. The actions taken are:

- Enter administrative data into the BOIP tracking system.
- Forward the BOIPFD, QQPRI, and requirements document to:
  - The Training Support Center (information)
  - SSC-NCR (information)
  - System proponent school (action)
- Receive the completed BOIP from the integrating center and forward to the Training Analysis Branch for comment.
- Enter the BOIP into the BOIP Master File.

- Forward to HQDA:
  - BOIP
  - QQPRI
  - Requirements documents
  - BOIP impact report
- Receive the approved BOIP from HQDA and publish it to all MACOMs for appropriate resource planning.

The BOIPFD/QQPRI/ROC package flow is shown in Figure 2.5.

Each branch (i.e., Armor or Field Artillery) service school has two major subdivisions which participate in the document review:

- Training Development - Responsible for MOS level instruction and preparation of the soldier qualification test materiel. The training developer performs the training impact analysis of the BOIP.
- Combat Development - Responsible for developing the:
  - Doctrine for the branch
  - TOE of the branch
  - BOIP (which will eventually change/replace the branch TOE)

The school which is proponent for the system (e.g., Air Defense Artillery School at Fort Bliss, Texas, for PATRIOT) will:

- Send copies of the package to coordinating schools if an MOS or TOE of their proponency is affected by the new system.
- Send a copy to LOGCEN for insertion of DPAMMH for all items of equipment (components and ASIOE) which have been type-classified. LOGCEN also enters the estimated DPAMMH for the developmental items into their MACRIT file.
- Expand upon the requirements document to develop the organizational and operational (O&O) concept.

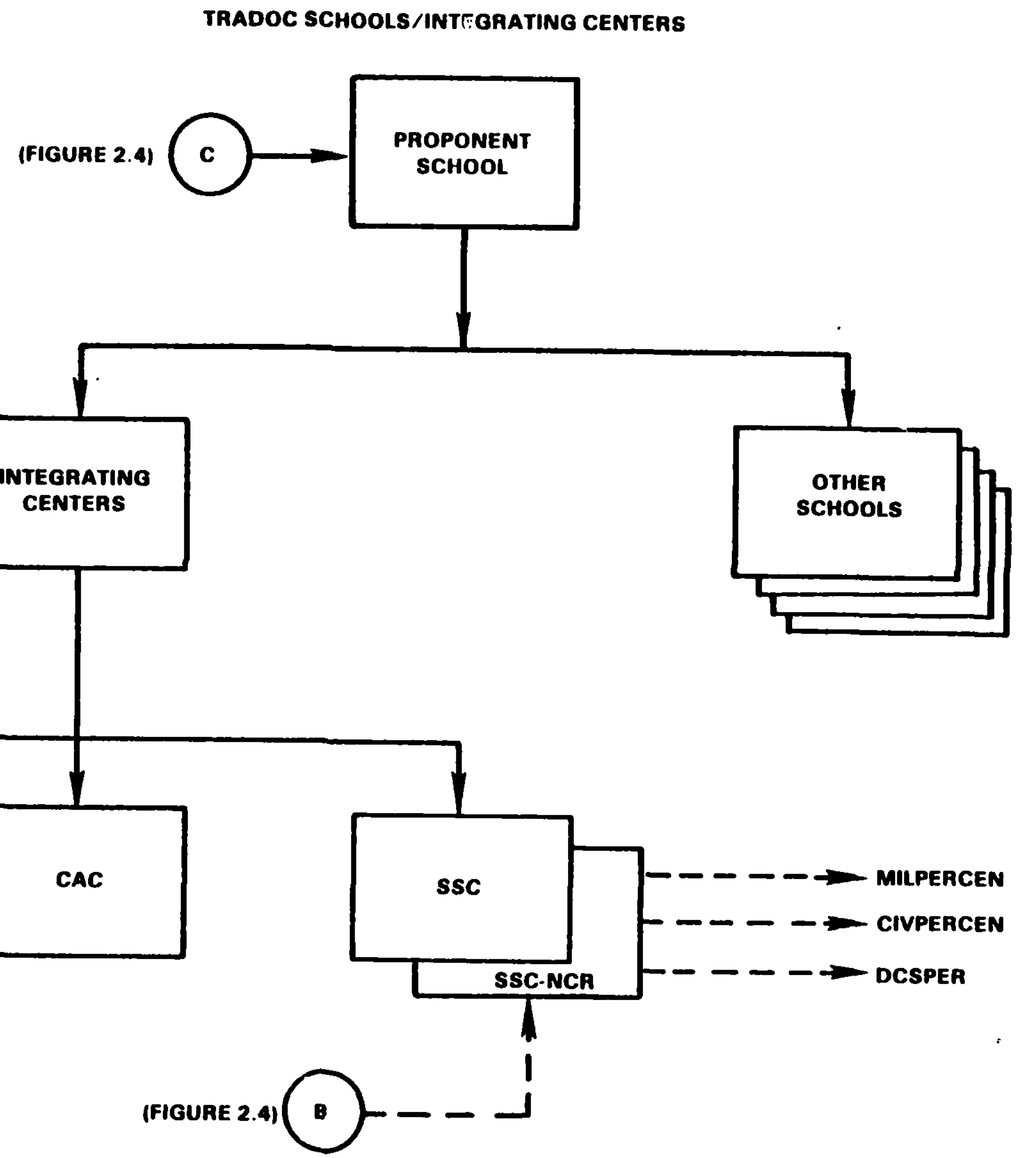

Figure 2.5. TRADOC Schools and Integrating Centers

- Based upon the O&O concept, determine which TOE will employ the new system.
- Determine the changes required (equipment and manpower) in each TOE to integrate the new system.
- Develop the BOIP (which will become a change to the TOE when the new system is adopted as standard).
- Forward the completed BOIPs (proponent and coordinating schools) to the appropriate integrating center.

Although interviews indicated this may be somewhat the ideal, the coordinating school should:

- Review the organizational and operational (O&O) concept to estimate (determine) the type of support each coordinating school could be expected to provide.
- Determine the equipment and manpower changes required in each TOE to support the new system.
- Enter the required changes into the BOIP.
- Forward the completed BOIP to the proponent school.

The integrating centers:

- Ensure the doctrine expressed in TOE is consistent and mutually supporting and supportable across branches. (For example, armor, mechanized infantry, and self-propelled artillery units are frequently cross-attached to form tactical task forces.) These integrating centers are:
  - Combined Arms Center, Fort Leavenworth, Kansas
  - Logistics Center, Fort Lee, Virginia
  - Soldier Support Center (SCC), Fort Benjamin Harrison, Indiana
- Forward the BOIP and QQPRI to HQ TRADOC (DCS-CD).

The SCC-NCR plays a unique role in the BOIP process. It is a TRADOC agency but performs supportability analyses for the ODCSPER. See Figure 2.6. The actions to be taken include:

- Coordinate with the Civilian Personnel Center (CIVPERCEN) when the QQPRI contains civilian occupational series changes. Coordinate with MILPERCEN when warrant or commissioned officer requirements may affect their occupational series.
- Compare the enlisted demand (i.e., BOIP impact) to the projected supply (i.e., the personnel data contained in the MILPERCEN data banks).
- Perform feasibility [career path and standards of grade authorizations (SGA)] and supportability (probability of acquiring the required aptitudes) analyses.
- Submit a formal MOS recommendation through HQ TRADOC to the DCSPER for decision.

HQDA. The primary Army Staff (ARSTAF) BOIP players are shown in Figure 2.7. The agencies and actions taken within ODCSOPS include:

- Requirements Directorate:
  - Is the BOIP coordinator for the ARSTAF.
  - Has the Force Integration System Officer (FISO) who is the ODCSOPS POC for the systems under development.
  - Prepares the HQDA position on the BOIP.
- Force Structure Directorate:
  - Uses the BOIP (and AURS) in LOGSACS to develop equipment planning requirements.
  - Uses the BOIP (and AURS) in PERSACS to develop manpower planning requirements.
- AFMCO [under HQDA Chief of Staff (CSA) administrative control and ODCSOPS operational control]:
  - Reviews the BOIP impact in relation to the force modernization master plan.
  - Monitors force modernization execution by MACOMs.

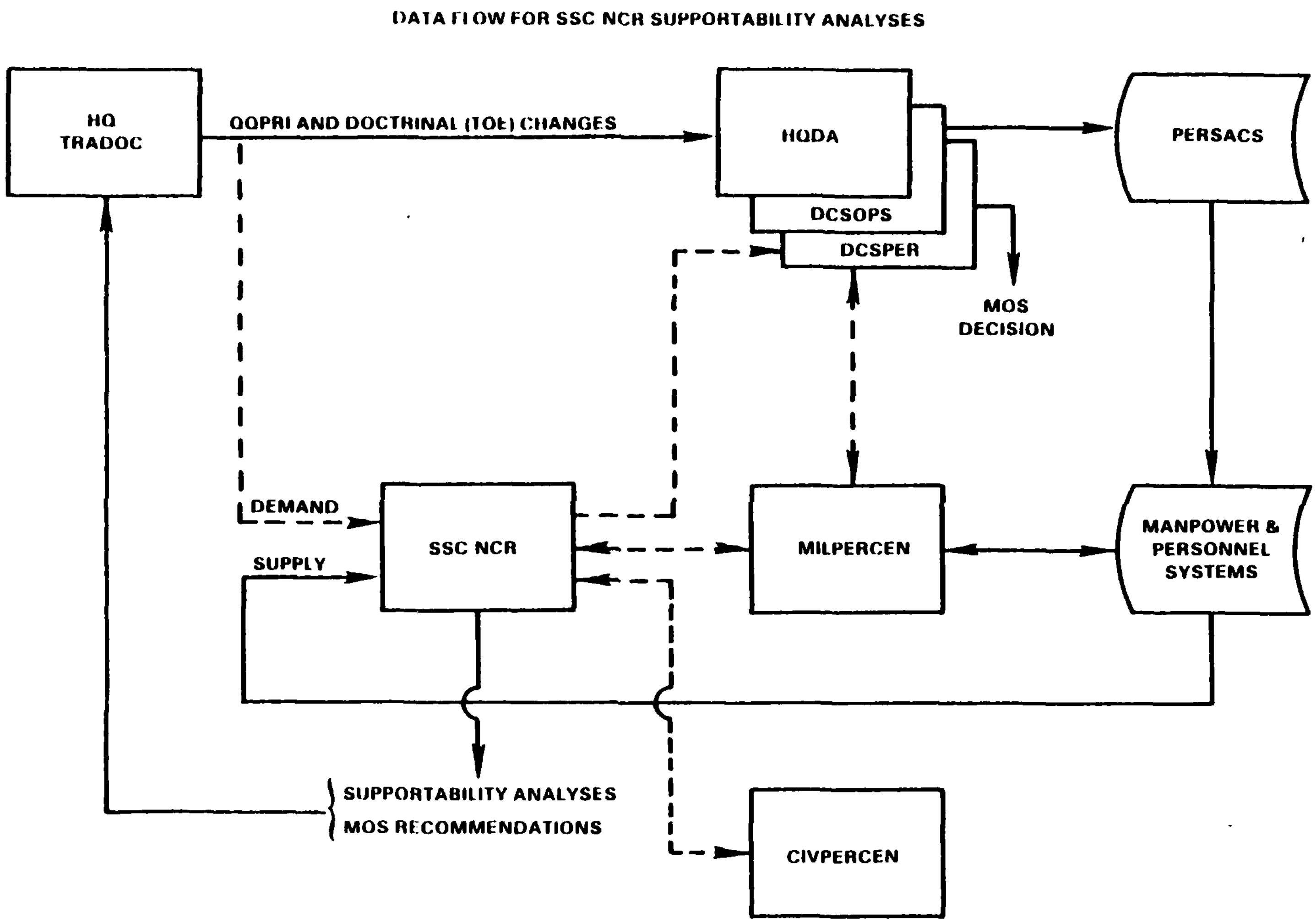

Figure 2.6. Data Flow for Manpower and Personnel Supportability Analysis

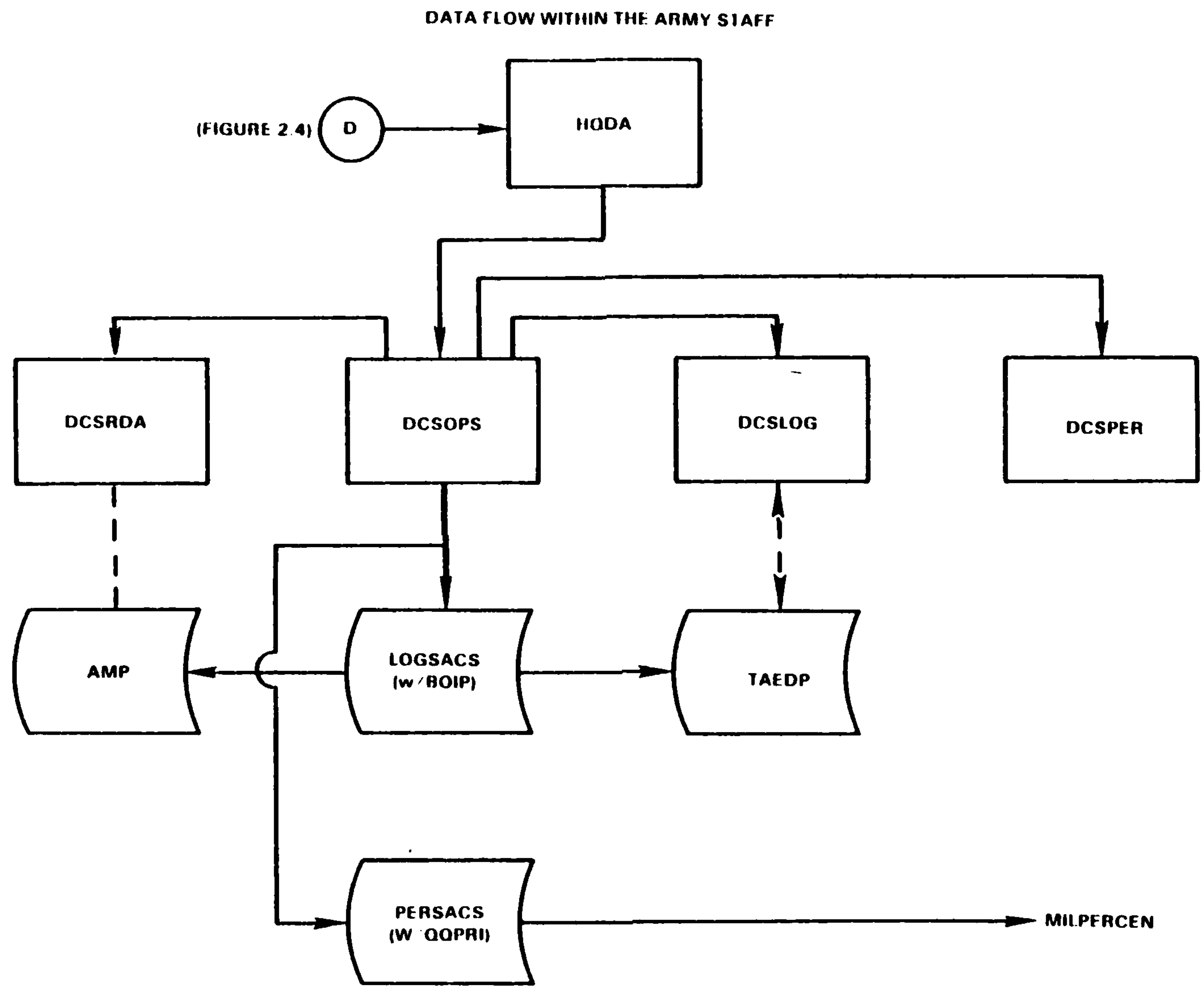

Figure 2.7. HQ Department of the Army BOIP Players and Flow

- Training Directorate:
  - Reviews the BOIP for training policy implications.

The actions within ODCSRDA include:

- Utilizing the LOGSACS in the automated Army Materiel Plan (AMP) which develops the AAO for procurement appropriation (PA) funded materiel.
- Participation by the HQDA System Coordinator (DASC) in AMP reviews at the MRCs to ensure the materiel requirements are properly stated and funded. Prior to the 1974 ARSTAF reorganization, each new system was representd by a single HQDA POC [the HQDA System Staff Officer (DASSO)], located within the Office of the Assistant Chief of Staff for Force Development (ACSFOR). Now the duties are split between organizations, the DASC in ODCSRDA and the Force Integration Staff Office (FISO) in ODCSOPS.

The actions within ODCSLOG are limited to using the BOIP (and AURS) impacted LOGSACS in the TAEDP for equipment distribution planning.

The agencies and actions within the ODCSPER include:

- Manpower Programs and Budget Directorate - Reviews the estimated manpower impact (spaces) in relation to the force ceiling and probable impact on the budget.
- Military Personnel Management Directorate:
  - SGA
  - Top six enlisted grade constraints
  - Command grade objectives

PROBLEMS WITH CURRENT PROCESS

<u>Information Dropout</u>

A considerable amount of "information dropout" occurs during the developmental cycle. For example:

- When the justification for major systems new start (JMSNS) is prepared, much data and information are available that are not captured and retained for later use. Therefore, manpower and organizational information that could establish the baseline information is lost.
- As stated in guidance documents and discussed at the 1982 QQPRI Symposium, TRADOC is the responsible MACOM in the developmental cycle until Milestone I or when the decision is made to designate a project manager; then responsibility is transferred to DARCOM. The methods of collecting data to that point have not been formalized; consequently, information passed to the PM is more a function of the PM's aggressiveness than that of the system.
- As their names suggest, the two milestone reporting systems, Force Modernization Milestone Reporting System and Integrated Logistics Support Milestone Reporting System (FMMRS and ILSMRS), do not contain detailed information content. These systems are progress reporting systems only. Various coordination and planning meetings are held by the materiel developer throughout the life cycle, but the logistics and NET analysts are rarely invited.
- A senior representative at SSC-NCR schedules Materiel Systems Reviews (MSR) for major systems approaching the First Unit Equipped (FUE) date. He stated a recent MSR uncovered 10 major planning discrepancies. However, there is no written checklist for the MSR, so a uniform replication across systems is unlikely.
- The BOIP preparer at the Ordnance Center and School stated most of his TDY trips (30-40 annually) involve seeking information about new systems which is not contained in the BOIPFD or QQPRI.
- Materiel developer information can be lost early in the development cycle by not transmitting it to the combat developer or deleting information when the QQPRI is returned to

the materiel developer on revision. For example, information on early MOS selections could contribute to the MOS decision process but usually is lost in document revision and handling.

LCSMM Timing Versus Information Availability

The LCSMM has event-oriented milestones while Army resource management has time-oriented milestones. A further complication is related to two new, high-level initiatives:

- The Carlucci initiative to compress the life cycle of major systems into a 5-year timespan.
- The CSA initiative to use the 9thInfantry Division as a high-technology testbed and to expedite its BOIP feeder inputs.

Other information contradictions are:

- MILPERCEN requires a 24-month notification leadtime to support new systems which require additional numbers of current MOS.
- MILPERCEN requires a 36-month notification leadtime to support new systems which require a new MOS.
- Typically, the 36-month threshold has occurred before the FBOIP/FQQPRI are submitted (see Figure 4-2, AR 71-2). Thus, the TQQPRI would be the basis for a timely new MOS decision. Historically, there has been little training information at this point so the MOS decision must be based upon intuition or experience with comparable systems.

Earlier MPT Information Is Required

Various studies have shown that a significant percentage of the RDTE funds have been committed by Milestone II; yet, the TQQPRI is not required at TRADOC until 9 months before that milestone; then TRADOC consumes about 7 months in preparing and coordinating the TBOIP. Therefore, the staffing of the BOIP impact report at HQDA and Milestone II can occur simultaneously. In addition to being untimely, the TBOIP impact report has these deficiencies:

- Historically, the total manpower requirements have only been reflected in the final BOIP (FBOIP) or amendments to the FBOIP.
- The TRADOC BOIP system can develop the manpower impact of one system but not the cumulative impact of all systems.

It is possible to have manpower estimates earlier in the life cycle if the notion of a conceptual BOIP[1] were accepted. It could be developed prior to Milestone I and could constitute a change to the baseline or the baseline against which subsequent input could be compared and evaluated. The details of the conceptual BOIP are in the section entitled Idealized Baseline.

Late Problem Detection

A synthesis of (1) the Man-Machine Interface study, (2) the DAIG investigation into the materiel modernization process, and (3) comments collected during field trips indicates most of the modernization problems (and their eventual effect on the MOS recommendation) could have been predicted (and thus prevented) by a structured method of high-level data collection, transmission, and evaluation. Below are some examples of problems undetected until late in the development cycle:

- The system attributes of the M1, M2, and M3 fighting vehicles and their subsequent effect on maintenance, and fuel and ammunition supply vehicles throughout the field army TOEs. The maintenance of the turbine engine presented unusual maintenance requirements previously not encountered.

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[1]Not to be confused with a condensed BOIP.

The fuel consumption significantly exceeds that of predecessor models. The ammunition carrying capacity of these vehicles, especially the M1, was less than the predecessor vehicle.

- In the two later problems, additional equipment and manpower are required to cope with the requirements for increased fuel and ammunition carrying capacity.
- The maintenance support equipment at DS/GS for the M2/M3 fighting vehicles.[1]
- The effect of the novel night vision devices and the unique distribution of flying tasks between the pilot and copilot of the AH-64 helicopter.

Our investigation revealed the development of manpower data must follow a particular series of sequential steps which can have a significant effect on the information quality:

1. Development by DARCOM of the BOIP feeder data sheet which should:

- List all parts that comprise the system. These include the developmental item, the components of the developmental item, and the associated items of equipment (ASIOE) needed to operate, maintain, and transport the developmental item.
- Describe the configuration of the developmental system to include its cubic displacement, weight, and electric power requirements.
- Describe the primary usage of the developmental system.

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[1]This problem was telephoned from TACOM to the Ordnance School BOIP preparer during our September 1982 visit; yet the first vehicles will be fielded in March 1983. The equipment will have to be funded by RDTE Appropriations because it is too late for Procurement Appropriations.

- List other items under development to which a single system is related (e.g., the PATRIOT consists of approximately 27 developmental items). Therefore, each of 27 BOIP must be considered together to assess the resource impact.

2. Development by DARCOM of the QQPRI (for the developmental system only) which includes:

- Operator requirements (quantity and MOS) for each system.
- DPAMMH required at each echelon of maintenance for the developmental item, to include its components.
- LOGCEN added annual maintenance man hours (AMMH) for any required associated items of equipment.
- MOSs recommended to perform the maintenance, on the developmental item only, at each echelon of maintenance requirements.

3. Development by the TRADOC proponent school of the organizational and operational (O&O) concept which will describe the doctrinal employment of the new system within the field army.

4. Development by the TRADOC proponent school of the equipment and manpower changes required in the TOE and documentation of them on the BOIP cover and continuation sheet to:

- Operate the total number of systems planned for each unit.
- Maintain all of the planned systems at the organizational level.
- Support the systems at the organizational level with system related equipment (e.g., additional fuel and ammunition trucks).
- Supervise the operators and the maintenance of the new systems and any additional support equipment.

5. Development by the TRADOC coordinating schools of the equipment and manpower (documented on the BOIP cover and continuation sheets) changes required in system-related support units TOEs throughout the field army. For example, to:

- Repair the system at the DS/GS level.
- Operate additional equipment needed in support organizations (e.g., the M1/M2/M3 cause both divisional and nondivisional fuel and ammunition truck requirements to increase).
- Calculate the AMMH to account for the increased equipment density to determine if additional maintenance manpower will be needed in the support TOEs.

What Are the Primary Problems?

Research uncovered several facts which seem to be contradictions, e.g.:

- Pro
  - The materiel modernization process is mature.
  - The DARCOM and TRADOC participants in the BOIP documentation process are intelligent, motivated, and conscientious about their work.
- Con
  - Equipment is being fielded for which there are no qualified maintenance personnel.
  - The MACOM commanders' and GAO's criticisms caused the CSA to direct the Inspector General to investigate the entire process.
  - The listing of problems described in the 1979 QQPRI Symposium was repeated in the 1982 QQPRI Symposium.

These contradictions suggest that the process usually defeats the efforts of the most diligent participants. Our research indicates the following specific discrepancies:

1. There is an Army-wide lack of understanding of:

- The QQPRI development process.
- The required role of each player in the QQPRI.
- The current utilization of the QQPRI.
- The potential uses for the QQPRI.[1]

2. There is no unbiased, objective, analytical method to develop the MPT demand data needed to support the MOS recommendation process. For example:

- Timing - The QQPRI-related activity initiation points are not well defined within the LCSMM, thereby causing a recurring, untimely response condition.
- Procedures - Are not sufficiently structured so as to lead respondents through the development of their contribution to the QQPRI.
  - The Army guidance (AR 71-2) does not contain specific instructions below the MACOM level.
  - Neither DARCOM nor TRADOC has published supplemental instructions to complement AR 71-2.
  - Of the agencies visited, only one had an SOP--which was due for revision.
  - With no published criteria, reviewers use subjective judgments to evaluate the submissions.
- Responsibilities Not Defined - There are no prescribed responsibilities or boundaries for each participant in the BOIP process. Consequently, several agencies validate the same elements of information. Conversely, some data (e.g., task lists) are usually omitted.

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[1]A related new initiative is the Force Modernization Impact Analysis System currently under procurement.

- Tools
  - Automation - Inadequately covers the information requirement; has an inadequate report generation and distribution scheme; and fails to support the analyst across organization boundaries.
  - MACRIT - There is no unbiased, objective, analytical method to both estimate and update the DPAMMH for all appropriate items of equipment (see Appendix E).
  - Training - There is no formal training program for participants in the QQPRI development process. This deficiency includes the lack of any training for the New Equipment Training (NET) analysts who initially develop the QQPRI in addition to planning the NET.
  - References - DA and subordinate agency publications treat the QQPRI development as a minor part of the materiel modernization requirement. Even the revised AR 71-2 (BOIP and QQPRI) dedicates more space to the development of equipment data than manpower data.

3. There is no centralized and automated source of MPT data. There are many opportunities to generate detailed MPT data during the materiel development cycle but there is no automated central repository in which to store/access it. For example:

- Before Milestone I - TRADOC is responsible for the collection of Integrated Logistics Support (ILS) information related to the system under development. The collected data are supposed to be transferred to DARCOM during the transfer of system responsibility but these data are not automated.
- Milestones I-III - The PM/MDC are appointed at or before Milestone I and subsequently are required to use the ILSMRS and FMMRS to record the achievement dates (but not the supporting details) of specified milestones.
- Milestones II-III - The TQQPRI are generated by NET analysts late in the demonstration and validation phase after

OT-I, if one is held. All QQPRI are forwarded to MRSA in hardcopy where they are given an administrative review and forwarded to HQ TRADOC; MRSA updates the FMMRS with dates and various codes but no MPT details.

- HQ TRADOC (DCS-CD) has two automated MIS: (1) a within-TRADOC BOIP tracking system, and (2) the BOIP master files which contain QQPRI-related data elements (e.g., MOS, quantities, and grade) but no more definitive data.
- HQ TRADOC (DCS-TNG) has an evolving MIS called the Task Descriptive Information System (TDIS) which is intended to be used by the service schools to record the task inventory for each MOS. The purpose of TDIS is to be the central source of tasks-within-MOS to support the development of Soldiers' Manuals, Job Aids, and Soldiers' Qualification Tests.
- TRADOC SSC-NCR has a task data bank to support the Comprehensive Occupational Data Analysis Program (CODAP) surveys. (It is not known whether TDIS and the CODAP data banks will eventually exchange information or perhaps be part of the same overall system.) There is no indication that either TDIS or CODAP will carry task priority and quantity by MOS. Without this information, the data base does not present task importance with respect to other tasks nor productive time required to accomplish a task. Without task productive time, task overload cannot be easily determined. Without task priority, task shred-out into two or more MOS (job) cannot be easily done except on a judgmental basis.
- HQDA uses the TRADOC BOIP magnetic tapes which include the QQPRI but does not insert additional MPT information.
- MILPERCEN has extensive personnel-related information in their MIS but they focus on managing personnel assets, the <u>supply</u> side, whereas the <u>demand</u> data come from the PERSACS (without BOIP applied), or from manually developed force modernization information. Even if the PERSACS reflected the change in demand based on the BOIP, the TOTAL BOIP

personnel demand under current PPBES practices would not be recommended within overall manpower constraints. Hence, there is no authority to provide assets based on BOIP demand.

- The planned ODCSOPS FMIAS concept is to use data from existing MIS; therefore, it can only provide additional MPT details if they are incorporated in modified feeder systems.

4. There is no unbiased, objective, analytical method to make an MOS recommendation by the SSC-NCR regardless of the MPT demand information developed during the QQPRI process. For example:

- There are four alternatives to each MOS recommendation:
  - Retain the old MOS.
  - Retain the old MOS and add an ASI.
  - Shred out the old MOS (this action creates new MOSs in the literal sense but does not mean that new, multiple tasks will have to be performed).
  - Create an entirely new MOS.
- But there are no formal rules to be followed which would lead one to select a specific alternative from the four listed above. Some of the people interviewed suggested these informal rules:
  - Retain the old MOS if:
    - There is no substantive change in the training course length.
  - Retain the old MOS and add an ASI if:
    - Only a few of the MOS holders will have to perform the tasks (e.g., equipment that is unit or MACOM specific).
  - Shred out the old MOS if:

-- There is job saturation (i.e., the number of tasks to be performed exceeds the ability and/or availability of the performer). There does not seem to ever have been a research effort conducted to systematically test this notion.

-- Task clusters are being formed around particular jobs. The clusters do not have to be mutually exclusive and, in fact, should stem from a common job core.

- Create an entirely new MOS if:

  -- The course content will be significantly changed.

IDEAL BASELINE

The purpose of the "ideal baseline" is to establish requirements for MANPERS processes and methodologies. The discussion immediately following focuses on systems and procedural aspects of the baseline; the development of a taxonomic tool to assist in MOS selection is detailed in the next section addressing Task 2. All of the recommendations addressed in this section are considered feasible and within the current state-of-the-art.

The preceding material addressed many problems related to the manpower and personnel requirements development process associated with materiel modernization programs. Many of these same problems were identified as early as 1979; yet, effective solutions have not previously been found. Some of the principal reasons are that:

- There is no overall manpower and personnel requirements development guidance that transcends the materiel development process from mission area analyses (MAA) to deployment so that cost comparison or manpower space trade-off analyses are included in all research and development stages of the acquisition process.

- There is no single, comprehensive "how-to" manual which integrates the materiel developer and combat developer developmental efforts with MACOM-unique requirements while simultaneously focusing on the principal objective--accurate resource estimates.
- The development of effective prescriptions, such as the aforementioned manual, requires an unbiased and analytical approach by a multidisciplinary, cohesive team. Army task forces and study groups rarely have the time and objectivity to accomplish such an effort.

Ideal Baseline Detailed Requirements

The "ideal baseline" for developing manpower and personnel requirements information must begin with a comprehensive record based on information developed during the MAA (i.e., analysis of threat, mission analysis, and current versus needed capabilities analysis). The record at this point in the life cycle would be data obtained from the manpower analysis associated with analyses mentioned. It would identify the type Army organizations that would be changed, augmented, or replaced by the desired or needed capability being studied, to include maintenance and support requirements. Since the type organizations involved include manpower identification by grade, skill, and numbers, the corresponding organizations in the Active Army, Reserves, National Guard, or unmanned units could be tagged as the trade-off baseline for this new capability. In the aforementioned analyses, an assessment of change could include the potential impact on the organizational structure (TOE) and such detail as change in number of manpower spaces and the rationale for such change. The change in manpower spaces would be further assessed concerning anticipated change to grade structure regardless of standards of grade authorization (SGA) constraints and skill. The assessment of skill impact would include the perceived change in aptitude area. The aptitude area impact would be required in all cases; even if at this early stage, perceptions are that there will be no change to the number of spaces or to the grade structure. The manpower and personnel requirements information developed in the pre-milestone I period would be automated immediately after the decision to proceed with the project. Table 2.1 proposes LCSMM information requirements. The manpower and personnel requirements information so established could be monitored and associated with cost and affordability analyses at decision points through each life-cycle phase until the capability under development is deployed. As changes occur to the information based upon more or improved knowledge of the emerging capability, the manpower and personnel requirements information could be appropriately updated. Such updates should occur prior to LCSMM milestone decisions so that senior managers and resource decision makers have available the most recent change that impacts upon affordability issues. Such change information could be displayed to reflect information changes since last milestone review and decision and change since the decision to proceed. Change would always be presented by organization, grade, and aptitude and skill.

The "ideal baseline" requirements for estimating manpower requirements would have attributes and capabilities as described below:-

- Centralized data base
- Input timing prompted by the system
- Structured data collection
- An automated report generation and distribution schema
- The use of abbreviated QQPRI during the conceptual phase of the life cycle
- A requirements document identification schema keyed to the LCSMM phases

Centralized Data Base

A centralized repository of information about each developmental system should be established; however, the structure of the data base is

TABLE 2.1

IDEAL BASELINE MANPOWER INFORMATION REQUIREMENTS

Milestone	Title	Information Requirements
	Mission Area Analysis	Organizations (type and number) Grades (anticipated or proposed change) Aptitude and skill (anticipated change
Pre-JMSNS	Concept Exploration	Conceptual QQPRI, BOIPFD, and O&O concept to establish the BOIP or AURS and update MAA information
I	Demonstration and Validation	TQQPRI, BOIPFD, and O&O concept to establish the BOIP or AURS and update Pre-JMSNS information
II	Full-Scale Development	FQQPRI, BOIPFD, and O&O concept to establish the BOIP or AURS and update I milestone information
III	Production and Deployment	AQQPRI, BOIPFD, and O&O concept to establish the BOIP or AURS and update II milestone information

Note 1: Information concerning the organizations, grades, aptitudes, and skills would be based on a capability in existence which would establish the manpower requirements baseline for trade-off purposes. Such baseline would be changed over the life cycle of the emerging capability until such time as the new system is type-classified and approved for deployment.

Note 2: In the event a capability is to be developed which does not supersede an existing capability, an initial anticipated force structure will be established for subsequent trade-off comparison purposes.

Note 3: Subsequent to Milestone I, the initial operational test (OT) and developmental test (DT) should take place. At this time a draft TOE may or may not be available for organizing the unit that will conduct the OT/DT. Such a draft TOE may or may not be in the TOE file. However, the draft TOE should supersede an AURS at the appropriate time, and such TOE will be officially introduced to the force structure.

critical to its usefulness. Most data bases are the products of an aggressive distillation and transformation of information, so that groups of words are represented by a single, abbreviated code. A more appropriate design would be similar to text or word processing systems with the capability of retrieval coupled with some electronic mail concepts. These techniques permit the system users to receive, send, and extract information and to be informed of current changes. The objectives of such a data base would be to:

- Improve the timeliness and accuracy of data being collected for use by other participants in the BOIP preparation process.
- Make available to all BOIP players information, however unrelated it may seem, which can help them form a more distinct perception of the task. Examples are:
  - Justification for Major System New Start (JMSNS)
  - Letter of authority (LOA)
  - Required operational capability (ROC)
  - Maintenance concept
  - Organizational and operational concepts
  - QQPRI
  - BOIPFD

Input Prompting by the System

The contradiction of the event-oriented LCSMM and time-paced QQPRI submissions could be reduced by selecting proximate milestones in the LCSMM and using them as "flags" for document initiation or revision. The optimal milestones will be developed during the MARMIS analysis.

As an interim solution, the FMMRS or ILSMRS systems could be used to generate reports with required activities and suspense dates.

The ultimate BOIP-oriented system will be AUTOMANPERS which should incorporate the attributes of: (1) the DARCOM milestone systems and

(2) the TRADOC BOIP tracking system. (Then those systems could be eliminated.) For maximum effectiveness, AUTOMANPERS would incorporate electronic mail capabilities to prompt for and distribute required BOIP inputs (e.g., QQPRI, BOIPFD, O&O, etc.).

Structured Data Collection

The multitude of previously described problems can be synthesized into these generalized categories:

- Boundaries of responsibility
- Knowledge and skill appropriate to the task
- Tools to assist the analyst in task performance

The most effective compensatory device to minimize these problems is a carefully conceived method of structured data collection, starting at the pre-JMSNS milestone and continuing through the research and development phases of weapon system development. This notion is analagous to having an experienced analyst lead the respondents through the BOIP development processes. While the structured method can be demonstrated in a manual mode (MANPERS), an automated procedure (AUTOMANPERS) should be the objective. AUTOMANPERS could contain an extensive system of user prompting, examples of appropriate input for different classes of equipment, and validity checks. In either case, the MANPERS methodology should recognize that the entire BOIP process needs to produce three broad categories of information:

- System Information (via BOIPFD)
  - System description (i.e., static characteristics)
  - System intended purpose
  - System performance characterics (not a current requirement)
- Performer Information
  - Tasks to be performed by operators, maintainers, and supporters

- Time required to perform maintenance tasks and their priority or importance
- Recommended number and classification of task performers and supporting rationale/logic

- Organization Information [via BOIP Organization and Operational (O&O) and Maintenance Concepts]
  - Number of systems per TOE
  - Concept of system employment by type organization
  - Concept of maintenance
  - Additional resources required to support the system

To extend the notion of establishing boundaries of responsibility around participating agencies, and to depict the idealized baseline procedures, a series of figures has been developed. The purpose of developing the figures was to reduce the apparent complexity of the BOIP process by graphically depicting the essential elements of information about each BOIP player. Supporting text will only be used to highlight concepts which might be overlooked.

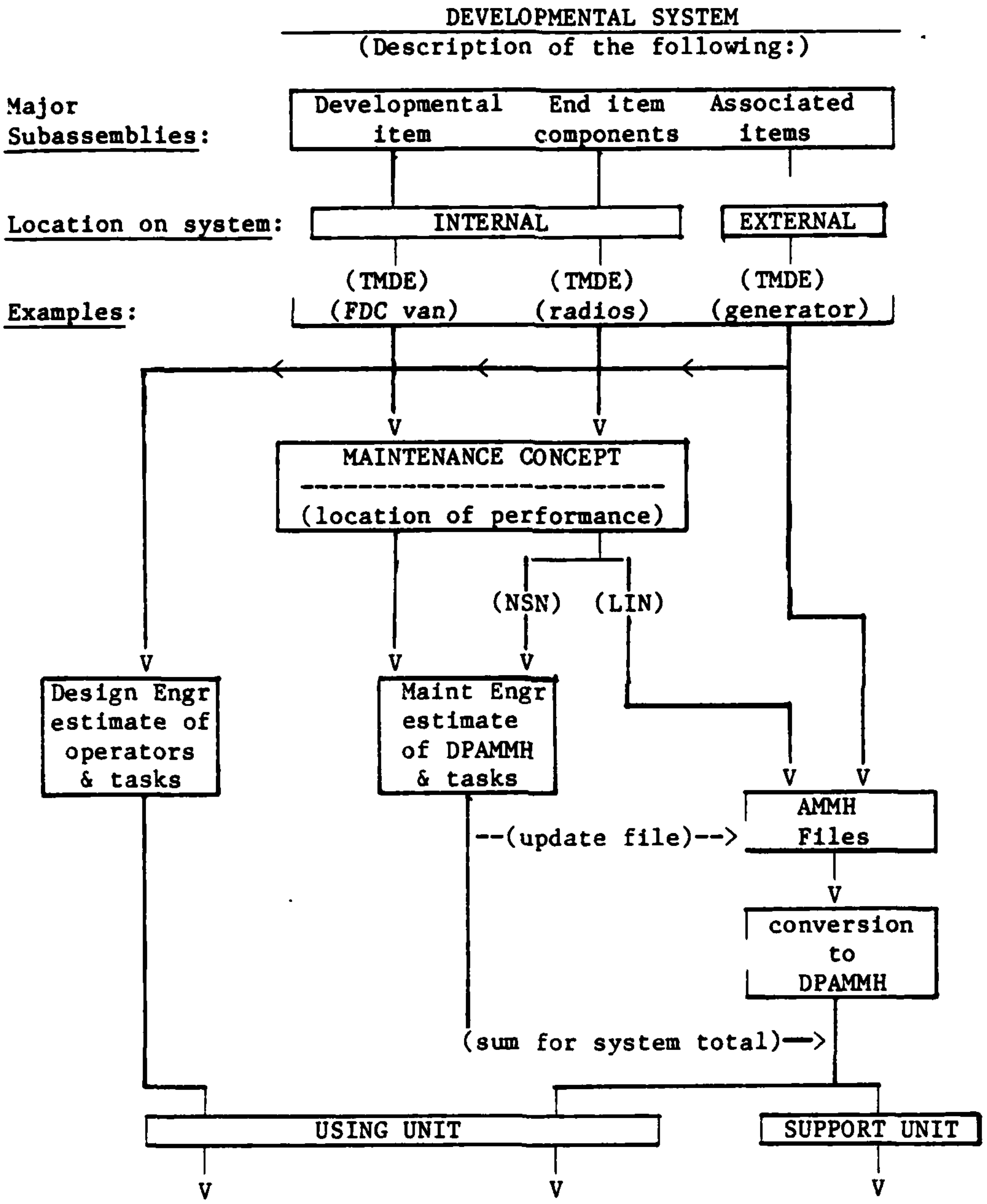
DARCOM

Figure 2.8 depicts the minimum essential elements of information (shown in solid boxes) required by the NET analyst to produce the output at the bottom of the figure.

The box at the top of the figure represents information which should be contained in the BOIPFD about the developmental system. The quality of the information in the BOIPFD is the foundation for all subsequent estimates. Historically, this information has not been accurate or complete and the quality of the QQPRI has been degraded. In particular, the BOIPFD should contain:

- A comprehensive description of the system and its intended use.
- A complete and accurate listing of components and ASIOE, to include test, measurement, and diagnostic equipment (TMDE).

SOLID BOXES DEPICT THE INFORMATION NEEDED BY NEW EQUIPMENT TRAINING (NET) ANALYSTS TO ESTIMATE THE MANPOWER REQUIREMENTS TO OPERATE/MAINTAIN/REPAIR A SINGLE MODERNIZATION SYSTEM



	ORG OPERATORS	ORG MAINTAINERS	DS/GS REPAIRERS
MOS	X	X	X
QTY	X		
DPAMMH		X	X
TASKS	X	X	X

Figure 2.8. Ideal Baseline Essential Elements of Information for the NET Analyst

The labels "internal/external" are intended to eliminate the recurring misunderstanding of the terms "components" and "ASIOE."

The remaining boxes represent information that the NET analyst must solicit as it is not provided automatically as is the BOIPFD. Since there are no manuals or training programs to aid the analyst at the present time, it is essential that sources of data and tools be specific to ensure consistent and quality results are produced in this process.

The maintenance concept describes the echelons of maintenance envisioned for the developmental item but not the entire system. The removable components and ASIOE are normally maintained in accordance with their Maintenance Allocation Chart (MAC) which is in the appropriate technical manual for each end item.

The NET analyst must obtain from the system developing engineer the task and skill information prepared as a result of the logistic support analysis which includes the estimated number of operators per shift, their descriptive title, and a listing of their tasks.

The NET analyst must obtain similar information from the maintenance engineer and will also request estimates of the DPAMMH for the items shown on the BOIPFD.

The MRSA or LOGCEN MACRIT files can be used for comparable item maintenance man-hours if a reasonable engineering estimate is not available.

The output of this process is shown at the bottom of the figure. Those are the required manpower-related entries for the QQPRI. Note that quantities of maintainers and repairers are not a QQPRI entry.

TRADOC-Proponent School

Figure 2.9 depicts the primary input and output of the BOIP analysts at the school which is proponent for the system.

At the left of the figure are equipment examples to show how the requirements increase as the process continues.

The proponent school automatically receives from DCS-CD three documents: (1) the materiel developer's BOIPFD, (2) QQPRI, and (3) the ROC or other requirements documents.

The combat developer must develop the O&O concept which will document the comprehensive plan for employing the system in various TOE. This process leads the analyst to the resource requirements to equip and man the receiving TOE.

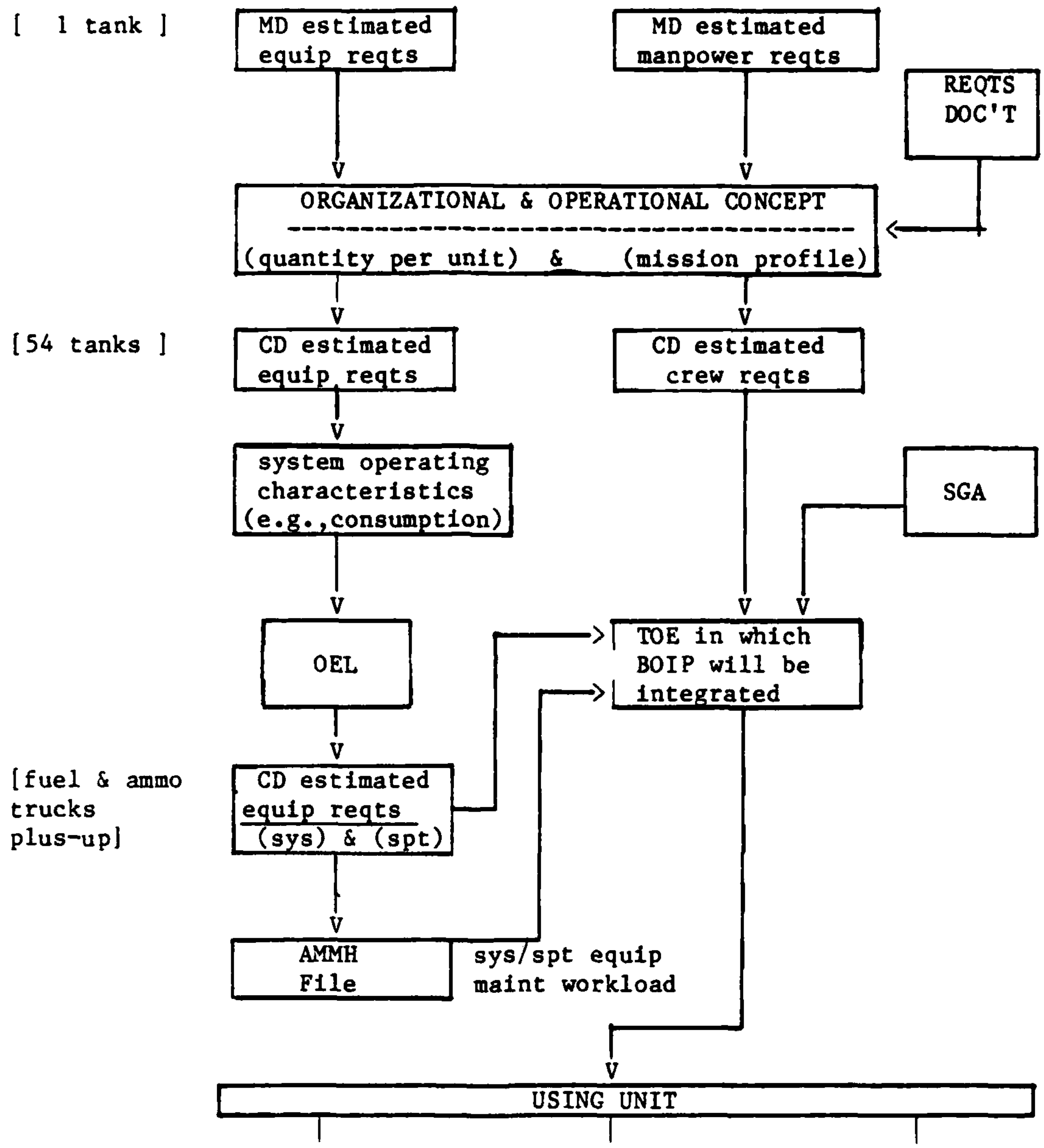
The box entitled "System Operating Characteristics" represents a recommended addition to the process. It is obvious from reading the DAIG and Soldier/Machine Interface reports that system performance characteristics may significantly increase support requirements. Figure 2.10 shows an approach which would compare the new system with a predecessor (if one exists) to obtain system distinctions. The system distinctions have the potential of becoming implicit tasks, and it is task information (e.g., difficulty) that affects the MOS recommendation.

The Organization Equipment Listing (OEL) is a relatively little known TRADOC product available in microform. The OEL inputs are: (1) TOE file, (2) BOIP file, and (3) TDA file from TAADS. The value of the OEL to the BOIP analyst is to identify every TOE which contains an item to be replaced. The product follows this sequence:

- Item of equipment
- TOE in which item is a requirement and the quantity

------------ TRADOC - PROPONENT SCHOOL (e.g., ARMOR SCHOOL) ----------

SOLID BOXES DEPICT THE INFORMATION NEEDED BY THE PROPONENT SCHOOL COMBAT DEVELOPER TO ESTIMATE THE MANPOWER REQUIREMENTS TO OPERATE/MAINTAIN/SUPERVISE ALL MODERNIZATION SYSTEMS WITHIN THE USING UNIT



	ORG OPERATORS (system)	(support)	ORG MAINTAINERS (sys + spt)	ORG SUPERVISORS (sys + spt)
MOS	X	X	X	X
QTY	X	X	X	X
GRADE	X	X	X	X

Figure 2.9. Ideal Baseline Information Requirements of the Proponent School

IDENTIFICATION OF POTENTIAL TASKS

CONTRASTING THE ATTRIBUTES OF THE NEW AND SIMILAR SYSTEMS
WILL PRODUCE NEW SYSTEM DISTINCTIONS
WHICH BECOME CANDIDATES FOR TASK STATUS

Hypothetical example: A tank similar to the M1 Abrams

SYSTEM ATTRIBUTES

HARDWARE CONFIGURATION		OPERATING CHARACTERISTICS	
Same	Unique	Same	Unique
	Engine = turbine		High thermal output
	Fuel type = *aviation*		40% higher fuel use rate
(oil capacity)			Complex oil changing procedures
(chassis)			Nose to nose towing due to high thermal output
(chassis)	Reduced ammo capacity		
(turret)	Fire control		Laser ranging

(Parenthetical entries would not be listed. They are shown only for illustrative purposes)

(Since there is no difference between the gun and its operation, neither entry would be made)

V

(105mm gun) . . . . (gunnery)

Figure 2.10. Identification of Potential Tasks Via System Attributes

- BOIP which will increase or decrease the same item of equipment (as a component or ASIOE)
  - The TOE to be affected
  - The quantitative change
- The same data for TDA units

EXAMPLE

Item	TOE/TDA	Qty/Chg	BOIP	Avail. Date
truck 5-ton	07045 (mech inf bn)	24		
		+2	TOW missile	830630
		-1	water purifier	840131
	15th station hospital	30		
		+1	medical set	840731

The result of the analysis is a listing of system-specific and supporting equipment requirements. These requirements must then be compared to the TOE in which the system will be integrated because the BOIP is rarely an absolute statement of requirements. Rather, it is a record of changes (+/-) to equipment and manpower requirements needed to integrate the new system into existing TOE. This fact is generally overlooked. The BOIP as a finished, usable set of data does not represent a requirement. Rather, it represents a requirements change. If a new weapon system establishes a totally new requirement, it would be recorded initially on AURS, then a draft TOE, followed by the approved TOE.

The equipment changes have maintenance implications so the AMMH file must be used to calculate maintainer requirements.

The standards of grade authorization (SGA) may have to be consulted to determine if supervisor changes are also required.

The product is the BOIP which contains changes to those TOE for which the school is proponent.

TRADOC - Coordinating School (Ordnance School)

Figure 2.11 depicts the process for the Ordnance School which is proponent for Ordnance TOEs. Since most developmental systems require DS/GS support, many must be submitted to the Ordnance School for analysis. For an accurate analysis, the Ordnance School BOIP analyst must have as input the proponent school BOIP. The reason is that the system-specific organizational requirements (e.g., 54 tanks) and the indirect requirements (e.g., added fuel and ammunition trucks) both represent an additional workload to the supporting maintenance units. While that conclusion seems obvious, the TRADOC BOIPFD/QQPRI distribution scheme is for concurrent not sequential evaluation, which makes it a MARMIS prescriptive candidate.

The maintenance concept is also needed by the Ordnance School combat development analyst to determine if maintenance doctrine will be affected by the support requirements of the new system. To a lesser degree, but for the same reason, the O&O concept would be a useful reference.

Again, the need for system characteristics was stated in field interviews because they can have an effect on the tools, special materiel handling equipment (MHE), and TMDE required in supporting maintenance units. As an example, the DS repair unit for the new hydraulic antenna mast (Magic Mast) will need a tool (similar to a hydraulic press) capable of holding a 35-foot antenna in two places.

As the maintenance support unit's workload and their own equipment requirements increase, there may be a need to increase operator, repairer, and supervisor manpower.

TRADOC - Coordinating School (Artillery School)

Figure 2.12 depicts the process for the other coordinating schools. The principal difference between the Ordnance School and the other schools is the emphasis on the O&O concept instead of the maintenance. The BOIP analyst must carefully analyze the O&O concept to

------- TRADOC - COORDINATING SCHOOL (e.g., ORDNANCE SCHOOL) --------

SOLID BOXES DEPICT THE INFORMATION NEEDED BY THE MAINTENANCE SCHOOL COMBAT DEVELOPER TO ESTIMATE THE MANPOWER REQUIREMENTS TO REPAIR THE <u>SUPPORTED UNIT EQUIPMENT</u> AND OPERATE <u>THEIR OWN INCREASED EQUIPMENT</u>

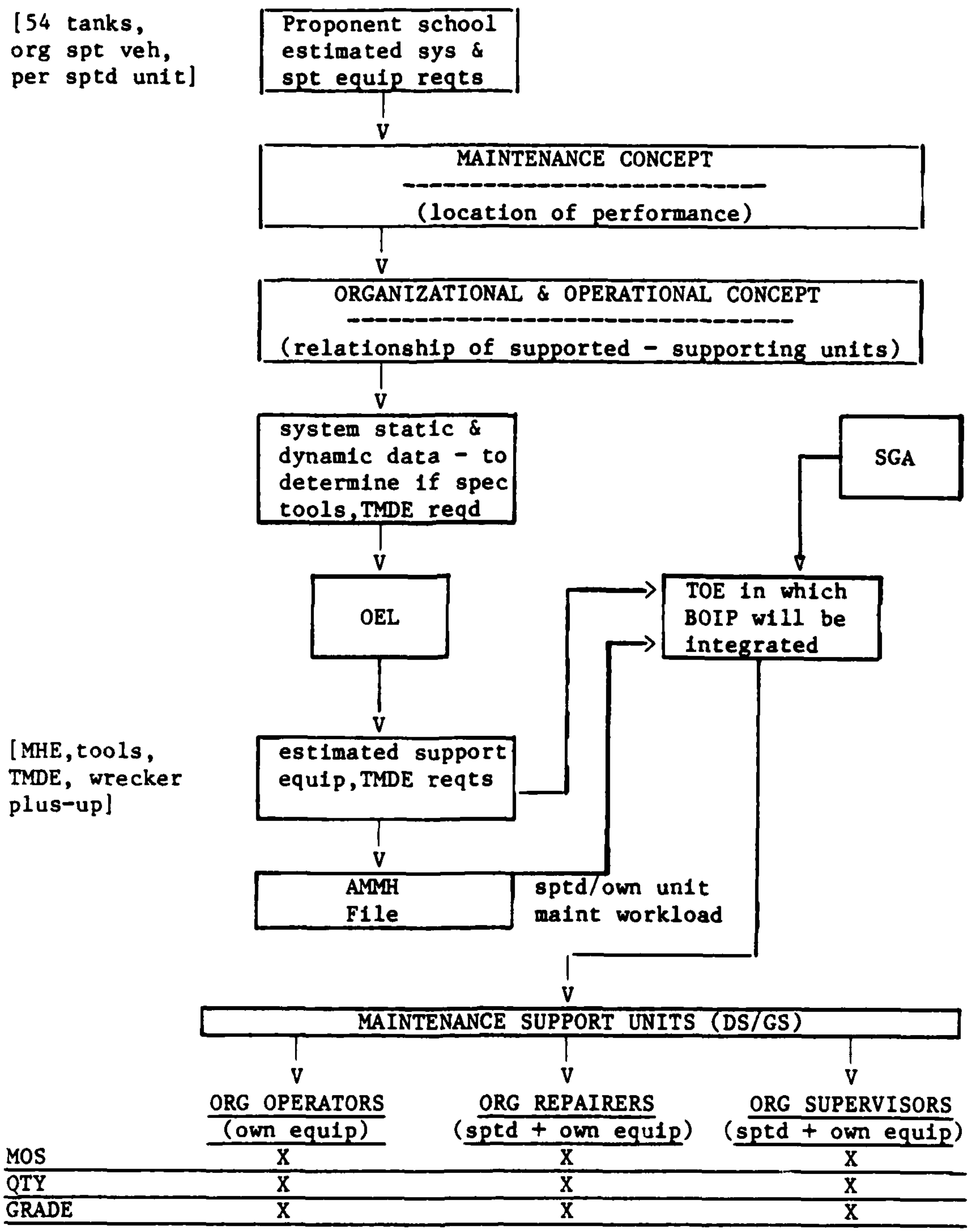


Figure 2.11. Maintenance Requirements - Ordnance School

------- TRADOC - COORDINATING SCHOOL (e.g., ARTILLERY SCHOOL) -------

SOLID BOXES DEPICT THE INFORMAION NEEDED BY OTHER COORDINATING SCHOOL COMBAT DEVELOPERS TO ESTIMATE THE MANPOWER REQUIREMENTS TO OPERATE/ MAINTAIN/SUPERVISE THEIR OWN INCREASED MISSION-ESSENTIAL EQUIPMENT

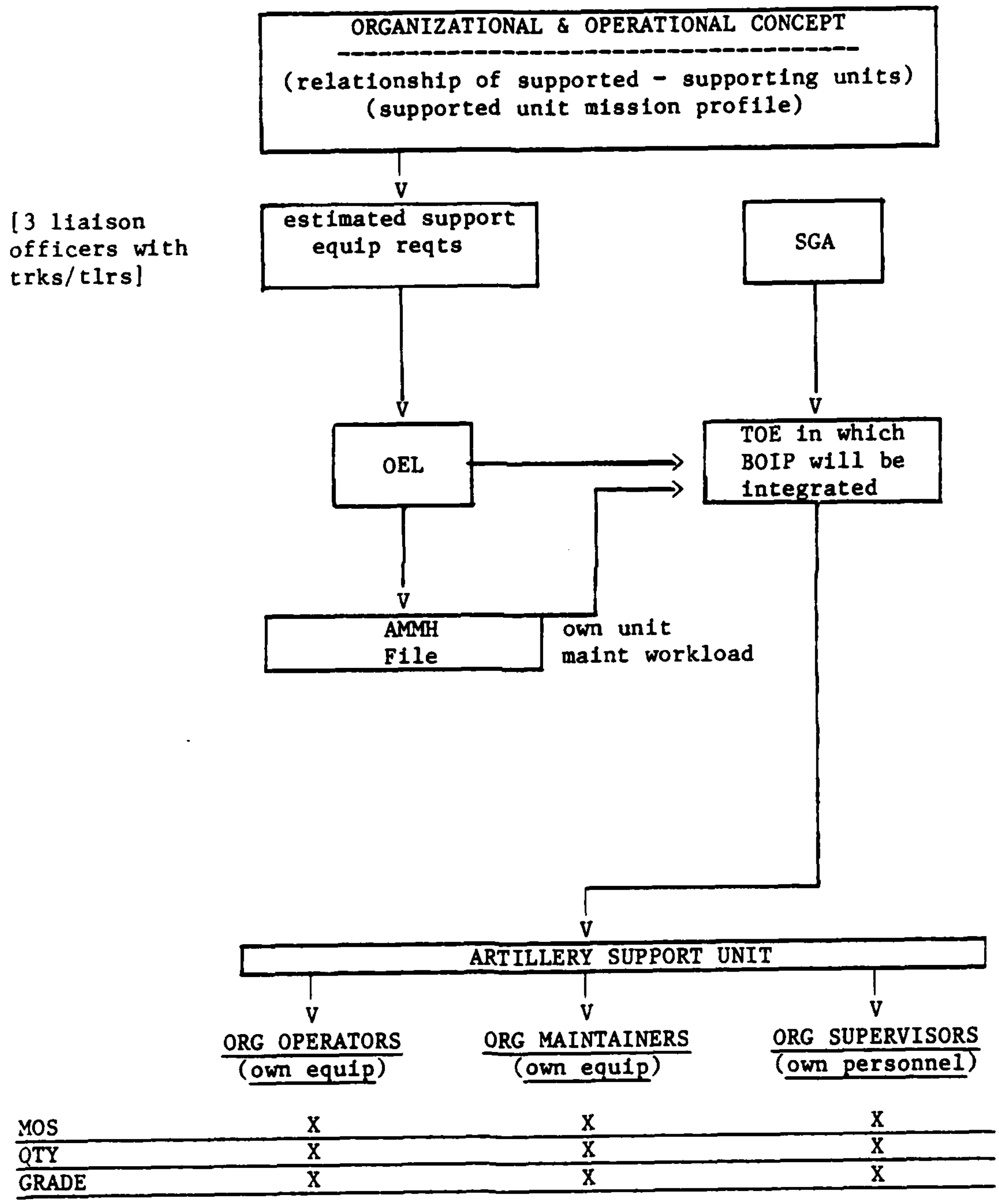


Figure 2.12. Coordinating School - Artillery School

determine if there are implicit support requirements, especially in divisional TOE. In the hypothetical requirements column on the left margin of the figure, we see a need to increase a supporting artillery TOE by three liaison officers (LNO) and their respective transportation.

The data at the bottom of the figure reflects the LNO as operators, and the analysis would have considered the increased organizational maintenance workload (six vehicle equivalents), as well as the possible change in supervisors.

Maintenance Impact

It does not seem evident to many of the personnel interviewed that the true maintenance impact of a new system is far greater than the QQPRI and maintenance concept imply. Figure 2.13 is provided as a reconciliation of the previously presented charts but focuses only on the maintenance implications. The accuracy of the maintenance man-hour estimate will depend on these factors:

- The validity of the maintenance engineer's estimate of DPAMMH for the developmental item.
- The validity of the man-hour data in the two MACRIT files for type-classified components and ASIOE (Appendix E is recommended reading).
- The accuracy with which each TRADOC proponent school analyst perceives the indirect support requirements in user organizations based upon unique system-operating characteristics.
- The accuracy with which each TRADOC coordinating school analyst perceives the supporting mission implied by the O&O concept.

TRADOC and HQDA

When the BOIP from all of the schools and the TDA requirements from MACOMs have been assembled, the package is forwarded to HQ TRADOC (DCS-CD) by the responsible integrating center.

THE TRUE MAINTENANCE IMPACT OF NEW SYSTEMS
HAS THE POTENTIAL OF INCREASING SUBSTANTIALLY AS THE QQPRI
PROCEEDS FROM THE NET TEAM THROUGH THE TRADOC COMMUNITY

(The impact is both directly and indirectly caused by the new system)

PREPARING AGENCY	EQUIPMENT CHANGED	MECHANIC INVOLVED	MAINTENANCE REQUIRED ORG	DS	GS	DEPOT

========================== DIRECT IMPACT ==========================

THE MATERIAL DEVELOPER DESCRIBES THE COMPOSITION AND MAINTENANCE REQUIREMENTS FOR ONLY ONE SET OF SYSTEM-SPECIFIC EQUIPMENT

PREPARING AGENCY	EQUIPMENT CHANGED	MECHANIC INVOLVED	ORG	DS	GS	DEPOT
New Equipment Tng team	1 tank	turret	X	X	X	
		track	X	X	X	
		radio	X	X	X	
		small arms	X	X	X	

THE PROPONENT SCHOOL INCREASES THE SET QUANTITY (AND MAINTENANCE REQUIREMENTS) TO CREATE PLANNED MODIFICATIONS FOR EACH TOE

V

PREPARING AGENCY	EQUIPMENT CHANGED	MECHANIC INVOLVED	ORG	DS	GS	DEPOT
Proponent School	(per tank bn) 54 tanks	turret	X	X	X	
		track	X	X	X	
		radio	X	X	X	
		small arms	X	X	X	

======================== INDIRECT IMPACT ========================

THE PROPONENT SCHOOL ALSO ADDS THE APPROPRIATE EQUIPMENT (AND ITS MAINTENANCE) REQUIRED TO SUPPORT THE PLANNED ORGANIZATIONAL SETS

PREPARING AGENCY	EQUIPMENT CHANGED	MECHANIC INVOLVED	ORG	DS	GS	DEPOT
Proponent School	(per tank bn)					
	4 fuel trks	wheel	X	X	X	
	3 ammo trks	wheel	X	X	X	
	1 recov veh	track	X	X	X	

THE COORDINATING SCHOOLS ADD THE APPROPRIATE EQUIPMENT (AND ITS MAINTENANCE) REQUIRED TO SUPPORT THE PLANNED ORGANIZATIONS

V

PREPARING AGENCY	EQUIPMENT CHANGED	MECHANIC INVOLVED	ORG	DS	GS	DEPOT
Coordinating Schools	(per arty bn)					
	3 1/4t trks	wheel	X	X	X	
for 3 FOs:	3 1/4t tlrs	wheel	X	X	X	

Figure 2.13. Maintenance Impact of New Systems

DCS-CD will merge all input into the BOIP Master file, forming a single integrated BOIP. Thus, the BOIP becomes a listing of all TOEs and TDAs which will be changed when the new system becomes adopted by the Army.

Figure 2.14 shows the process required to develop the BOIP impact report. DCS-CD maintains a current copy of the HQDA force structure which is a listing of all units (and all components) existing or planned for activation/deactivation over time. The BOIP is applied to the force structure which will produce the total equipment and manpower changes which are reflected in the BOIP and required to integrate the new system into the force structure. At this time, however, no PPBES actions have been taken to resource the BOIP requirements.

The boxes at the bottom of the figure are a reminder that the true system impact is dependent upon each school analyst recognizing the need to modify all TOE appropriate for the support of the new system.

As the text in the figure points out, the BOIP impact report is the total resource implication, which is unphased.

The TRADOC and DA staffs review the BOIP, impact report, and requirements document as a package. It is either approved or returned for change and resubmission.

TRADOC (SSC-NCR) and HQDA

The Army DCSPER and the SSC-NCR are responsible for affordability, feasibility, and supportability analyses. The accuracy of these analyses is dependent upon being able to compare the manpower demand and personnel supply over a time continuum. It is difficult to portray the impact manually (i.e., spread sheets) because:

- The force structure file contains the planned Army-90 (conversion to light-heavy divisions) changes.

SOLID BOXES DEPICT THE INFORMATION NEEDED TO ESTIMATE THE TOTAL MANPOWER REQUIREMENTS TO OPERATE AND SUPPORT EACH OF THE MODERNIZATION SYSTEMS

FORCE STRUCTURE

(quantity of each type unit)

V

will be the multiplier for each system BOIP

(there are 600+ systems under development)

V

EACH SYSTEM TOTAL BOIP WILL CONSIST OF THE FOLLOWING

V	V	V
USING UNIT BOIP	MAINT SPT UNITS (DS/GS) BOIP	OTHER SPT UNITS BOIP

NOTE: The BOIP are not time-phased when this computation is performed at HQ TRADOC. Each BOIP contains the date the first system is available; and the BOIP impact reports will reflect the total system impact on that single date.

Figure 2.14. QQPRI-BOIP Impact Report Development

- Many of the systems under development (more than 600) will be fielded in the same time frames, and these intervals coincide with Army-90 changes.

The Army Staff is currently developing the capability to apply the BOIP to PERSACS with an estimated availability date of second quarter FY1983. Phasing data are presently being developed by ODCSOPS, system proponent for PERSACS. Figure 2.15 depicts the impact of phasing the BOIP to support the required analyses.

Report Generation

The current DARCOM and TRADOC management information systems (FMMRS, ILSMRS, and BOIP tracking) are not generating reports appropriate for use by the BOIP participants. In addition, the reports are not distributed across MACOM organization lines.

The degree of success achieved by the ARMPREP initiatives will be positively correlated with the timely and accurate transmission of information needed by each BOIP participant. In addition to recurring reports produced by batch processing, the system should have a user-friendly, ad hoc report writing capability.

Figure 2.16 is provided to stimulate thoughts about feasible automated tools which could be incorporated into AUTOMANPERS.

All of the files shown could be controlled by a data base management system (DBMS) and, where data element redundancies are shown, the DBMS would collapse the files for economies in processing.

Many of the interviewees stated a need for various kinds of reports which would be feasible with such a system configuration. Some feasible combinations are:

- Merging the SSN (a generic or "family" of items file) and MACRIT file would provide:

SOLID BOXES DEPICT THE INFORMATION NEEDED TO ESTIMATE
THE TOTAL (TIME-PHASED) MANPOWER REQUIREMENTS TO OPERATE AND SUPPORT
EACH AND ALL OF THE MODERNIZATION SYSTEMS

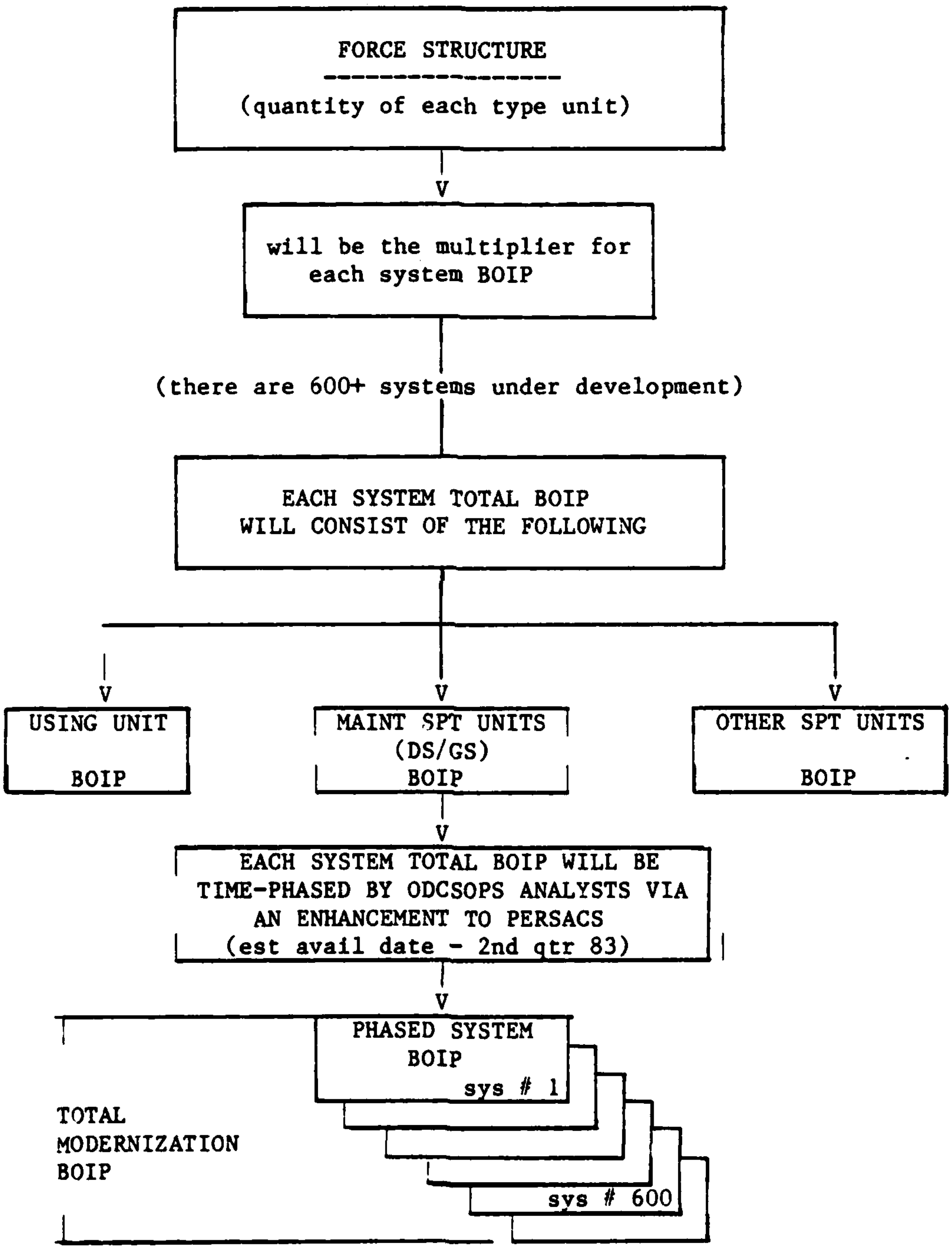


Figure 2.15. Phasing QQPRI-BOIP Requirements

ALL OF THE DATA BASES DEPICTED IN THIS CHART
COULD BE MERGED VIA TWO DATA ELEMENTS (LIN & MOS)

FILE	DATA ELEMENTS							
SB 700-20	Item name	LIN	MRC	NSN	NSN name			
SSN X-REF	Item name	LIN		SSN	SSN name			
OEL	Item name	LIN				TOE	TOE name	QTY
						BOIP	BOIP name	CHG
TOE	Item name	LIN		MOS	Psn name	TOE	TOE name	QTY
MACRIT	Item name	LIN	-->	MOS				AMMH
AR 611-201				MOS	Psn name	Duties		
CODAP				MOS			Tasks	

POSSIBLE PRODUCTS FROM THE MERGER

(Any combination of these categories)

EQUIPMENT				WORK	MANPOWER				ORGN	CHANGE
SSN	MRC	LIN	NSN	AMMH	MOS	Psn	Duties	Tasks	TOE	BOIP

Figure 2.16. Potential Sources of Information for QQPRI-BOIP

- AMMH for the 5-ton vehicle fleet (to include a comparison with the planned 10-ton conversion)
- AMMH implications of the aviation unit conversion plan
- AMMH for avionics versus ground communications

- Merging the OEL and MACRIT files would provide:
  - The current AMMH by MOS (or total) for each TOE
  - The change in AMMH for each (or all) TOE as each (or all) BOIP item is integrated into the TOE
  - The individual and cumulative effect of BOIP on numbers required of an MOS

Other files (e.g., PERSACS) could be incorporated into the designs which would provide a very powerful analytical tool.

Use of Conceptual BOIP

It is feasible to obtain MPT information earlier in the system life cycle via the use of a conceptual BOIP. It should have the same general format so it can be machine processed with existing ADP programs for impact analysis. However, its distinctions could be:

- Preparing it with the Concept Formulation Package (CFP) or immediately following the CFP.
- Omitting much of the administrative data, such as the system scheduling dates (actually, that data should be eliminated from the current requirement).
- Using dummy MOSs whenever the selection of a current MOS is closer to guessing than to analyst conviction. If a standardized format were used, the dummy MOS and descriptive title could be entered into MOS work files for accountability. (Use valid developmental LIN and SSN as there is nothing to gain by using dummies.)
- Use of comparable item DPAMMH in lieu of the engineer estimate--but clearly identify the origin as a reminder.

The remainder of the BOIP contents would be unchanged.

The development of a conceptual BOIP is a cognitive challenge because the preparer is dealing with abstractions. To elicit system concepts from the developing engineer and provide them with a presence by writing a system description and assigning them LIN and MOSs will require a special analyst. If this notion is accepted, the idea of selecting and training a small team of analysts should also be considered.

Change of BOIP Identification Schemes

The current method of identifying BOIP documents (i.e., T and F) does not connote the LCSMM phase of development. Phase information would be useful because: (1) early documents can be expected to contain less detail, and (2) later documents must be given a more rigorous evaluation.

The various system tests (DT and OT), which are critical milestones, can also be expected to result in new information. If the QQPRI and BOIP were keyed to the LCSMM phases, then passing a milestone could require a mandatory submission from each participant. Naturally, "no change" would be an acceptable submission and would provide an audit trail.

Taxonomy

The use of structured procedures to assist in and standardize the development of MOS recommendations is considered a key part of the "ideal baseline." The taxonomic structures addressed in the Task 2 discussion which follows have the potential for meeting this need although additional development, in conjunction with the completion of Tasks 3 and 4, is required.

OTHER AREAS FOR IMPROVEMENT

MACRIT

The early assessment of the impact of a new system is usually measured in terms of the total number of spaces involved and the estimated maintenance workload (which will be translated into maintenance spaces). Consequently, the NET analyst must have a timely, accurate, and easy-to-use source of maintenance man-hours in order to provide consistent quality QQPRI. The two separate (and different) MACRIT files that presently exist do not fulfill this requirement.

There is an ongoing effort to improve the LOGCEN MACRIT file. At this time, information pertaining to specific improvements is not available. However, discussions with LOGCEN representatives indicate that some of the problems described in Appendix E are candidates for improvement.

MACRIT should be analyzed in relation to the observations listed in Appendix E and the following prescriptions:

- Develop a MACRIT users' guide.
- Improve the current MRSA file and/or its interface with the LOGCEN file.
- Integrate the MACRIT file into AUTOMANPERS.

Training Program

There should be a formal training program for all contributory participants in the QQPRI and BOIP development process. It is obvious that the task is too complex for the analyst to become proficient from a manual alone. Well designed job aids can prompt recall, but they are not a substitute for training.

Our interviews indicated the NET analyst spends less than 25% of the time on QQPRI; therefore, refresher training may be required from time to time.

TRADOC Process Management

The current distribution scheme of BOIPFD and QQPRI within TRADOC is for all players to receive them simultaneously. The idealized baseline method suggests an O&O concept should precede the BOIP preparation.

Perhaps a more effective way to do it would be to convene the key players at the system proponent school. There, the combat developer element would brief the O&O concept to all the players, then hold working sessions to develop the concepts for support. When all participants are conceptually in agreement, they would return to their home station for the development of specific OQPRI and BOIPFD followed by the BOIP.

SUMMARY

This section has covered the development of personnel requirements information beginning with the preparation of the BOIPFD, followed by the preparation of the QQPRI, and ending with the BOIP, which is a manpower and equipment change document. The elapsed time for this overall process generally takes up to 1 year, but it is not unusual for the elapsed time to extend to 2 years or more. The process (BOIPFD and QQPRI) is initiated in DARCOM. TRADOC prepares organizational changes (BOIP) based on information gathered in the process. The TRADOC product, which is a comprehensive organizational change statement, covers both equipment by LIN and SRC (and UIC) and personnel by MOS, grade, quantity, and SRC (and UIC). The BOIP must be approved by HQDA (DAMO-ROR in conjunction with other ARSTAF) and published as a TOE change in the consolidated change table (CCT) before it is an accepted change to be input to documenting units by UIC.

In this overall personnel requirements information development process, there is no recognized technique to establish an early manpower baseline for subsequent comparison. If such a capability were established, manpower affordability and supportability change information would be more easily discerned.

A complete conceptual QQPRI requirement should be established, and such a requirement could be implemented immediately. It should be required as a part of the concept formulation package and serve as an early manpower requirements statement and to identify early training problems.

Information that may aid in the decision processes at HQDA and perhaps at TRADOC can be lost in processing the BOIPFD and QQPRI to formulate the BOIP and MOS decision recommendation (and the MOS decision itself). Candidate MOS selections and the reasons therefore can be and frequently are lost in the process of coordination, review, and revision in the overall BOIP preparation process. Requirements to perpetuate initial and all subsequent selections of candidate MOS should be established. When initial selections of candidate MOS are rejected in the coordination and review process, the reasoning for such actions and the logic driving a subsequent candidate MOS selection should be included in the QQPRI and BOIP documentation process. Procedures and job aids should reflect these requirements.

The MACRIT data maintained at the LOGC and at MRSA represent DPAMMH and AMMH. In addition to a conceptual difference, there are other variations between these data because of frequency and method of update. There should be one MACRIT data base, and all MACRIT users should utilize the one source. While this would benefit the Army overall, it would also reduce resource requirements to maintain MACRIT data.

The development of manpower information is not given attention similar to that given the development of equipment information. Establishing manpower information seems to be of secondary importance realizing that equipment operations, maintenance, and support is the workload that establishes the need for manpower. The responsibility for QQPRI preparation is vested in the NET Team Manager, who has a primary responsibility of training and prepares the QQPRI only as an additional duty.

This responsibility should be recognized as a part of the manpower development responsibilities, and it should be vested in a manpower personnel developer (which should be established).

The term basis of issue plan (BOIP) has been around for over 2 decades. The term BOIP lacks overall personnel, equipment, and organizational connotations. It should be replaced with a more relevant term. Some suggestions are:

(a) Personnel and Equipment Change of Requirement (PAECR) (pronounced PACER).

(b) New Weapon Systems and Associated Equipment and Personnel Requirements (NAEPR) (pronounced NAPER).

(c) Personnel and Equipment Requirements Change (PERC).

(d) Equipment and Personnel Requirements Information (EPRI).

(e) New Weapons Systems Fielding Requirements (NWSFR).

DEVELOPMENT OF TAXONOMIES TO DERIVE BEHAVIORAL REQUIREMENTS FOR NEW ARMY SYSTEMS

BACKGROUND

This section presents the development of a taxonomy to derive behavioral requirements from new weapon system task descriptive data (TDD). Extant taxonomic systems are reviewed and assessed as to their utility for the manpower and personnel requirements determination process. A taxonomic model tailored to an Army context was developed on the basis of this literature review. The model contains two taxonomies, one for determining the MOS for a new equipment system and one based on tasks.

Objectives

The objectives of Task 2, as listed in the Statement of Work, are to:

1. Review existing task and data taxonomies having potential utility for deriving manpower and personnel requirements

2. Assess the utility of each taxonomy

3. Develop, use, or adapt a taxonomic model based upon requirements established in Task 1. The model should:

   - Define data input, processes in behavioral requirements derivation, and taxonomic output

   - Use data congruent with that available at each phase of the Life Cycle Systems Management Model (LCSMM)

   - Address Army Military Occupational Specialty (MOS) content

4. Identify and define the elements of the taxonomic model

This section presents current methods for determining MOS for developmental items and the development of the taxonomies. A later section presents methods for using the taxonomies.

LIFE CYCLE AND PERSONNEL PLANNING PROCESSES

Life Cycle System Management Model

The Life Cycle System Management Model (LCSMM) is an event-oriented sequence of specified phases of program activities and decisions which culminate in the development and fielding of equipment or weapon systems described in detail in Task 1. This management process weighs mission needs against capabilities, established priorities, and resources. Mission Element Need Statements (MENS) are prepared for approval by the Secretary of Defense to justify major new system acquisition. As Rhode et al. (1980) report, this approval completes the Mission Area Analysis Phase and constitutes authority to proceed into Milestone 0 (program initiation) and subsequent LCSMM phases. These phases are identified and described below:

1. Concept Development - acquisition approaches, such as the technical approach, economic approach, and military usefulness are established and the program is formally initiated. The completion of this stage is Milestone I.

2. Demonstration and Validation - decision baselines are refined through the analysis and quantification of alternative design concepts, and preferred solutions are established to reaffirm the need. The completion of this phase is Milestone II.

3. Full-Scale Development - design, fabrication, and testing of the total system (including support) are completed to establish the basis for the production decision and the use of production resources. The completion of this stage is Milestone III.

4. Production and Deployment - the total system (including support) is production-engineered, fabricated with production tooling, and fully tested for operational worth. The operational system and its support are produced and delivered to inventory. When inventory objectives are complete, the program is transferred to commodity management. Concurrent with full production, inventory items are delivered to operating forces. User reports establish modification and overall requirements, and the system is operated and maintained unil classified as obsolete. The completion of this stage is Milestone IV.

Qualitative and Quantitative Personnel Requirements Information (QQPRI) and Basis of Issue Plan (BOIP) in the LCSMM

This section describes the Qualitative and Quantitative Personnel Requirements Information (QQPRI) and Basis of Issue Plan (BOIP), depicts their location within the LCSMM, and examines their relationsips to other critical documents in the LCSMM. The data which serve as input to the QQPRI and BOIP, the decision processes entailed, and the output which results from their use are considered.

According to AR 71-2 (1982), the Basis of Issue Plan Feeder Data (BOIPFD) is the first document the materiel developer (i.e., DARCOM) prepares that triggers the QQPRI and the BOIP process. Specifically, the Logistics Analyst/Materiel Systems Coordinator (LA/MSC) of the Materiel Development Command (MDC) generates the BOIPFD based upon input from the developing engineer and supporting Materiel Readiness Commands (MRCs). A BOIPFD is prepared for each new or improved system and describes the modernization equipment. The BOIPFD, which is forwarded to the New Equipment Training (NET) team and the Equipment Authorization Review Agency (EARA), is amended when major cost increases are identified, associated support items of equipment (ASIOE) requirements change, or component items change. EARA reviews the feeder data for validity, completeness, and accuracy; ensures that the BOIPFD and Standard Study Number (SSN) cross reference files are compatible; and sends information copies of DARCOM items or systems feeder data to HQDA. No specific time-frame or point in the LCSMM is identified by AR 71-2 for submission of the BOIPFD.

The NET analyst prepares the QQPRI from the BOIPFD during the LCSMM demonstration and validation phase. According to AR 71-2 (1982), the QQPRI is a compilation of organizational, doctrinal, training, duty position, and personnel information. It determines the need to establish or revise an MOS and to prepare plans to provide the training and personnel required by the system. Figure 3-1 describes the seven QQPRI requirements and the data in them.

According to AR 71-2, logistics support analysis (LSA) is applied to the system to accommodate the data needed to support the QQPRI (AR 71-2, 1982). The materiel developer provides task and skill information resulting from this LSA. Additionally, the NET analyst receives information from the developing engineer, supporting Material Readiness Commands (MRCs), the maintenance engineer, the Manpower Authorization Criteria (MACRIT) file, and AR 611-201. After developing the tentative QQPRI (TQQPRI), the NET analyst submits it to the Materiel Readiness Support Agency (MRSA). Similarly, EARA forwards the BOIPFD to MRSA, which reviews both documents for compatibility, completeness, and accuracy. Upon meeting these criteria, these documents are sent to HQ TRADOC at least 9 months prior to Milestone II.

In reviewing the MOS recommendations, TRADOC analyzes the BOIPFD and TQQPRI. Here, the proponent school develops the organizational and operational concept (O & O Concept), determines which table of organization and equipment (TOE) will employ the new system, and develops the Basis of Issue Plan (BOIP). The tentative BOIP (TBOIP) is developed from the BOIPFD and TQQPRI and it contains equipment and personnel changes required to integrate the modernization system into existing TOE. For those systems requiring the development of a new TOE, an Automated Unit Reference Sheet (AURS) is prepared. This document is used to estimate materiel and personnel requirements in the Structure and Composition System (SACS) until TOE are developed (AR 71-2, 1982, p. 4-3). Meanwhile, the Deputy Chief of

Requirements	Data and Description
1. Statement of Requirement or Procurement Directive	- Identity of document and preparer - New Equipment Training Plan (NETP) number - Identity of action officer and date prepared
2. Description of Equipment to be Generated and Maintained	- Identification of special test equipment and support requirements - Description of equipment in terms of generic nomenclature and Line Item Number (LIN)
3. Direct Productive Annual Maintenance Manhours (DPAMMH)	- Number of hours required by MOS for each category of maintenance (organizational, direct support (DS) general support (GS) and depot). - Provided on the principal item, associated items not type-classified, major components, and support and test equipment. - Statement of standard LIN and the generic nomenclature
4. Number of Direct Operators	- Operators needed to make up a crew or operate the system as a single shift
5. Duty Positions	- Listing, by descriptive title, required for operation and support of the equipment - Suggested placement of duty position within a current, revised, or new enlisted MOS - Excludes skill levels, includes MOS that support the maintenance levels of all associated equipment
6. System Unique Duties and Tasks	- Listing of duties and tasks to be performed in positions requiring new, revised, or current MOS - Indication of whether current MOS are adequate for the new or improved system
7. Individual Training Plan (ITP) Note: Only relevant if contractor or New Equipment Training (NET) is used to qualify personnel for test and evaluation	- Copy of the ITP - If not shown in ITP, provide name of contractor, title and length of course, duty positions for which the course trains, and prerequisites for attendance

FIGURE 3-1
QQPRI REQUIREMENTS AND DATA

Staff for Combat Development (DCSCD) at HQ TRADOC prepares an impact report and forwards the TQQPRI, TBOIP, and requirements documents, which contain the O & O Concept, to the Soldier Support Center (SSC) for incorporation of MOS information. The SSC submits a formal MOS recommendation through HQ TRADOC to HQDA Deputy Chief of Staff for Personnel (DCSPER) for review. At this point, a TRADOC review board is convened to determine whether the TQQPRI, TBOIP, and Required Operating Capability (ROC) are mutually supportive and to ensure that minimum mission essential resource requirements are stated. This process consumes approximately seven months. The QQPRI and BOIP can be modified through an iterative procedure when changes are warranted, although the final QQPRI (FQQPRI) must be completed at least 21 months prior to Milestone III and 33 months before the equipment availability date (EAD). TRADOC forwards these materials to the Office of the Deputy Chief of Staff for Operations and Plans (ODCSOPS) Requirements Directorate (DAMO-RQR) within Headquarters, Department of the Army (HQDA). Ultimately, HQDA makes the MOS action decision.

CURRENT METHOD FOR DETERMINING MOS

MOS must be determined for direct operators and maintainers and for support personnel; the divisions of this section correspond to those two kinds of MOS determination.

Direct Operators and Maintainers

MOS determination has several stages starting with MOS for maintenance personnel at the time of Milestone 0. This MOS estimate serves as a constraint in the Logistic Support Analysis Record (LSAR) to discourage developers from designing equipment that no one can maintain. The method is similar to the one used for QQPRI but is more rudimentary.

The process of determining MOS of direct operators and maintainers and support personnel in the QQPRI has four steps:

1. Initial MOS recommendation by the New Equipment Training (NET) analyst, accompanied by a task list or

2. Processing by affected agencies, particularly TRADOC and the TRADOC school that eventually conducts training

3. Revised MOS recommendation by Soldier Support Center National Capitol Region (SSC-NCR), resolving conflicts such as personnel supply and requirements, and constraints on personnel assignments

4. Final approval of the MOS by DCSPER

The products of ARMPREP are designed to facilitate the initial and revised MOS recommendations.

Initial MOS recommendation

The initial MOS recommendation is the responsibility of the materiel developer, with input from the contractor who develops the materiel system. New Equipment Training (NET) analysts often are former military instructors, but they are not colocated with design engineers nor with the analysts at SSC-NCR who reconcile requirements and constraints in MOS recommendations. The NET analysts use information from engineering specifications, LSAR, and AR 611-201.

The NET Analyst may use AR 611-201 to identify all plausible MOS for each position. A comprehensive list of possible MOS may be identified in the index, which lists all MOS by Career Management Fields (CMF). Some of these MOS may be eliminated by consulting CMF diagrams, which are presented on the first page of each section. Finally, the specification for each remaining MOS may be read to determine appropriateness. Each MOS specification has two sections: first is a general description that differentiates the MOS from other MOS, and second are detailed descriptions of the job duties and tasks, equipment, qualifications, and grade structure. Sometimes more than one reasonable MOS can be identified for each position; often a single MOS is identified, but occasionally no existing MOS is a reasonable match for the requirements. This method of using AR 611-201 is logical and comprehensive, but in practice it is subject to shortcuts, depending upon the skill and thoroughness of the NET analyst.

MOS are either system-specific or generic. System-specific MOS identify one particular materiel system in their title (e.g., Improved HAWK Pulse Radar Repairer is MOS 24J). Generic MOS identify a functional class of equipment (e.g., Defense Acquisition Radar Operator is 16J) or more than one system. If a new weapon were added to a system-specific MOS the title and definition would have to be extended; a new MOS seems a likely alternative. System-specific MOS are concentrated in missile and armor systems where there are few generic MOS.

Other considerations in MOS selection are the complexity of the new Army system and the impact on training time. Complexity of performance includes the ways that the job functions are allocated and executed (e.g., maintenance functions). Technological complexity increases training time, and may exceed the amount that will be allowed in the revised MOS recommendation process.

Examples of system-specific MOS are provided by the PATRIOT and TOW systems. PATRIOT is a complex Air Defense (AD) missile system, and all such systems have system-specific MOS. Combining the PATRIOT with an existing missile system in a single MOS would have created a job with too many duties and tasks, and with more required training time than is feasible.

The Tube-launched, optically tracked, wire-command link guided missile (TOW), unlike PATRIOT, is an infantry anti-tank weapon, and such infantry weapons are usually within the responsibility of the generic MOS, 11B, Rifleman. The TOW, however, differs in deployment from other infantry weapons and is more technologically complex and expensive. High performance standards were needed to use its capabilities and a dedicated operator was required. The TOW operator, therefore, has an MOS (11H) separate from the other infantry MOS.

Not all complex weapon systems with long training requirements have system-specific operator or maintainer MOS. For example, all aviation MOS are generic, but helicopter maintenance could hardly be considered a simple skill by any criterion. Servicing and limited repair of helicopters is based on class; e.g., Attack Helicopter Repairer. More extensive maintenance problems are referred to component specialists; e.g., Aircraft Power train Repairer. Experience with a kind of component apparently transfers across systems. The current pattern of specialization encompasses all of helicopter maintenance.

A new MOS is likely to be needed if the most similar existing MOS is system-specific. If MOS for similar, existing jobs are generic, then they are likely to cover operation and maintenance of the new system.

Problems arise in initial MOS identification because of the lack of information, lack of experience of the NET analysts, and volume of AR 611-201. The NET analysts have MOS determination as an extra duty that they perform infrequently, and they have limited sources of information.

AR 611-201 is so voluminous that the analyst is likely to fail to find relevant MOS or narrow the selection to the best one. The process has no standards or written procedures. Documenting the process and developing an organized method for use of AR 611-201 are, therefore, two solutions that are likely to benefit initial MOS identification.

The QQPRI requires a task list or exceptions to an existing list for each new position. Without task lists, it is hard to tell whether an MOS selection is correct or not. The QQPRI is also supposed to have estimates of DPAMMH. Often the QQPRI is late, not accompanied by task lists, or is otherwise incomplete; even when TQQPRI and FQQPRI are submitted by the required deadline, much of the value of the information is already lost (e.g., for TASA and design of training).

Processing of initial MOS recommendations

The QQPRI, including MOS recommendations, is processed through various agencies, particularly TRADOC and its schools, as diagrammed in Task 1. It is eventually forwarded to SSC-NCR, where final MOS recommendations are made.

Final MOS recommendation

The final MOS determination has four alternatives in cases where there was a current MOS to select:

1. Confirm the MOS without change.
2. Add an Additional Skill Indicator (ASI) to specify skill on the new equipment.
3. Shredout a new MOS from the old one. ("Shredout" is the creation of two MOS to replace an existing one).
4. Create an entirely new MOS. (This generally amounts to confirming a need that was recognized much earlier, during the conceptual phase of development.)

SSC-NCR relies on training estimates and data from TRADOC and Army service schools in making final MOS determinations. SSC analysts weigh other factors, many of which are statutory or administrative; e.g., career advancement paths and overseas assignments. The training or skill factors, however, are the ones relevant to behavioral processes.

SSC-NCR accepts as much as 40 percent increase in original training, or six months of training on the job, to bring MOS incumbents to an acceptable level of performance on the new system (as a general rule). That magnitude of increase is likely only when the old MOS is responsible for only one system, which is almost always a system-specific MOS.

The absolute length of training is also held to a minimum. MOS for complex systems may be system-specific in order to reduce total training time. There is a required minimum of twelve weeks of training, including both basic and advanced individual training (AIT) which overlap in one-station unit training (OSUT). Soldiers therefore receive a minimum of six or seven weeks of AIT.

An ASI to indicate capability with the new equipment within the old MOS is the second option. An ASI is appropriate when the new equipment requires most of the skills of the old MOS, but also some substantially different ones. Current practice allows as many as six ASI connected to an MOS. An ASI is not intended as a temporary solution, so it is not supposed to be used if the old system is replaced over a short period of time. Similarly, ASI are not supposed to be used with courses that prepare people for one-time assignments, because the ASI is an administrative device to identify people for reassignment to a particular kind of duty.

If an MOS is identified, incumbents are given New Equipment Training (NET) to man the new system during testing and when it is fielded. If the MOS is not considered sufficiently similar to the requirements of the new system, there is a shredout into separate MOS. Shredout of generic MOS may occur even when the new system imposes only a small increase in equipment for the MOS if it increases the total training tasks over the threshold of what is desirable. Then, the systems associated with the old MOS are likely to be divided between the newly created MOS. The time for shredout to take effect depends on whether the old MOS is satisfactory for an interim period.

Subsequent training requirements related to MOS determination

Data in the QQPRI related to MOS determination are used subsequently for the systems analysis of training, including Task and Skill Analysis (TASA) and instructional system development (ISD). These developments begin with a listing of tasks for each MOS; such listing is facilitated by a task taxonomy (Matlick, Berger, Knerr, and Chiorini, 1980). The taxonomic system needs to structure task lists so that training can be designed for categories of tasks, rather than piecemeal. This approach enables training to be designed for a category of tasks even when the listing is incomplete.

Support MOS

The QQPRI is required to list support MOS as well as operators and maintainers of the system being developed; the majority of MOS listed in the sample in AR 71-2 (pp. B-3 and B-4) are support MOS. Identification of support MOS requires generating a complete list of all the services needed for the developmental item and the MOS for these services. A related requirement in AR 71-2 (p. B-1) is a list of all components and associated equipment; input data for it are provided in BOIPFD. These requirements may be much more important for predicting total manpower impact of a new system than the few MOS of direct operators and maintainers.

METHOD IN TASK 2

Methods for achieving the Task 2 objectives included interviews, analysis and assessment of taxonomic literature, and development of new taxonomies. Project staff interviewed Army personnel who are responsible for manpower and personnel projections and MOS determination. The interviews were conducted at two levels in SSC-NCR. First was an overview of SSC-NCR responsibility and the Comprehensive Occupational Data Analysis Program (CODAP) system, and second were detailed discussions with personnel in the MOS structure division.

In conducting the literature review, we compiled a list of selected references which span a variety of taxonomic approaches, system development methodologies, and other classification schemes. The primary data sources include Natinal Technical Information System (NTIS), Defense Technical Information Center (DTIC), Research and Development Information System (RDIS) searches, published bibliographies, professional journals, and other literature dealing with taxonomic and classification approaches.

Documents identified in these searches were examined to determine key characteristics of taxonomies, methods for generating taxonomic units, and uses and constraints of taxonomic systems. Analysis of the literature first focused on general criteria for evaluating taxonomies. The specific purposes of ARMPREP were identified and formal criteria for assessing the utility of extant behavioral taxonomies were delineated in terms of their ability to assist in making manpower and personnel requirements decisions.

These formal criteria are listed below:

1. Behavioral Focus

2. Objective

3. Not Requiring Observation

4. Discriminate Among MOS

5. Descriptive of MOS

6. Familiar Terms for Subject Matter Expert (SME)

7. Consistent with Army Practices

8. Facilitates Decisions

These ARMPREP taxonomic criteria were applied to historical approaches to task classification and behavioral taxonomies. Matrices that depict the interface between these taxonomic systems and the formal ARMPREP criteria were constructed. Generally, each classification system fails to meet some of the formal criteria for the development of an ARMPREP taxonomy; specifically, many taxonomies do not satisfy the four following requirements (of the eight listed above):

1. Description of Army MOS - most taxonomies are delineated at a too molecular content level and do not contain common Army concepts

2. Objective - many taxonomic systems rely upon subjective judgments and possess limited reliability

3. Behavioral Focus - many systems lack this focus, instead emphasizing behavior description or ability requirements

4. Consistent with Army Practices - many taxonomies are too general to be technically adequate

The assessment determined that AR 611-201 best fulfills the formal criteria for the ARMPREP taxonomy. While AR 611-201 was not designed as a taxonomy, the MOS information it contains forms an implicit, underlying taxonomic base. The detailed review of taxonomic systems and assessment of their utility for ARMPREP is contained in Appendix F. The following sections describe the method for generating the ARMPREP taxonomy from the MOS-related material in AR 611-201.

DEVELOPMENT OF MOS STRUCTURE AND TASK STRUCTURE TAXONOMIES

The taxonomic system was developed by content analysis of MOS titles and specifications from AR 611-201, according to the requirements of ARMPREP specified in the Statement of Work (SOW), and elaborated under Task 1 of the project. The system has two taxonomies:

1. The MOS structure taxonomy which is oriented along lines of equipment, CMF and organizational structure of the Army
2. The task structure taxonomy, which classifies behavior requirements.

MOS Structure Taxonomy

The objective was a taxonomy to guide initial MOS selection by providing a way to narrow the possible MOS to a few alternatives, while retaining MOS that qualify. The information for the taxonomy is contained in AR 611-201, particularly the table of contents, the CMF structure diagram at the beginning of each section, and the delineation of job duties in MOS specifications. This taxonomy is valuable as a guide for using relevant cues in MOS selection, by organizing the large volume of detail in AR 611-201.

The MOS titles for direct operators and maintainers were sorted into clusters that satisfied the requirements of ARMPREP, and each cluster was named. The first cue used in the sorting was the MOS title (e.g., Aircraft Powerplant Repairer) which placed the MOS within a major area (e.g., Aviation) and a minor cluster within that area (e.g., Aircraft Component Repairer). When that cue was not sufficient, cues were sought from the CMF structure and the MOS specifications. Track Vehicle Mechanic (63Y) and Track Vehicle Repairer (63H), for instance, are both designated "Machinery Maintenance," as opposed to "Weapon System Maintenance" which is used to designate maintenance MOS for tanks and armored personnel carriers. The specification of Track Vehicle Mechanic specifically excludes duty in "self-propelled field artillery, armored, mechanized infantry, and armored cavalry units;" therefore, these MOS were classified as Engineering MOS.

The same cues placed each MOS in the Army organizational structure, so that the taxonomy represents kinds of equipment and units to which the incumbents are assigned. Unit affiliation and kind of system, along with operator-maintainer distinctions, are defining characteristics of MOS in virtually every case. Types of performance required (e.g., driving vehicles, or using test equipment) are less important, and less relevant in determining MOS.

Table 3-1 presents the MOS Structure Taxonomy.* Major systems are covered in sections numbered 1.1 through 1.7 of Part 1, and secondary systems in sections numbered 1.8 through 1.11. Sequencing of sections is arranged so that adjacent sections cover related functions to highlight areas of possible contention between the various Army centers and schools (e.g., Armor, Infantry, etc.).

The taxonomy is hierarchical, so the meaning of any particular category is predicated on the major divisions of which it is a part; for example, the location of Track Vehicle Mechanic (63Y) and Track Vehicle

* The tables are located at the end of this section.

Repairer (63H) in the engineering equipment section (1.8) means that the user might overlook the stipulation that 63Y does not serve in combat units, or the designation of both 63Y and 63H for mechanical systems, rather than for combat systems. The subordination in Table 3-1 distinguishes it as a taxonomy, rather than an arbitrary classification. The hierarchy, and procedures for its use, are designed to facilitate the use of AR 611-201 to determine MOS and task lists for developmental items.

MOS in Part 1 of the MOS Structure Taxonomy are open to soldiers at the entry level, except for three specifically-defined MOS (in IHAWK and NIKE systems under AD Missile Systems, section 1.5.4 in the taxonomy). MOS for a particular kind of system are listed together, regardless of whether they are for operators or maintainers; however, the operator status and the level of maintenance for each MOS are indicated in the columns at the right side of the table. Operators and maintainers are grouped together to highlight MOS associated with a particular kind of equipment, especially those that both "operate" and "maintain."

Operators and maintainers are occasionally in separate but adjacent categories within a class of systems, when they involve different subclasses. More than one category of MOS may need to be considered for a developmental item especially when MOS are responsible for maintenance in two areas; such cases have footnotes. For instance, fire control computers and fire control instruments for both armor and artillery are maintained by the same MOS (34Y and 41C, respectively).

Connections between categories are rare, indicating that MOS are divided according to equipment characteristics. The kind of equipment is the dominant consideration in selecting MOS for direct operators and maintainers, and the kinds of tasks performed with that equipment are of secondary interest.

Part 2 of the MOS Structure Taxonomy includes supervisory and other MOS that are associated with equipment functions that correspond with sections of Part 1. A common numbering system is used for both parts of the Table to facilitate finding all MOS associated with a particular system.

Part 2 of Table 3-1 also identifies related MOS for requirement 5 of QQPRI, so that the BOIP reflects the organizational impact of the new system. Identification of MOS in "support chains," which consist of MOS affected by broad classes of systems is a related endeavor. Weapon systems depend on ammunition specialist and transportation personnel as well as combat soldiers, for instance. Support chains of MOS will be required for Manpower and Personnel Requirements Determination Methodologies (MANPERS), and Parts 1 and 2 of the MOS Structure Taxonomy apply to that requirement.

Part 3 is included to ensure exhaustive consideration of all MOS; however, the characteristics of these MOS (e.g., band members) have no particular application for MANPERS. This part also includes MOS for reserve forces. Although some of them are direct operators or maintainers, they are primarily applicable to emergency or wartime needs associated with skills found in the private sector. Thus, they are distinguished from operators and maintainers who are Part 1 of the MOS Structure Taxonomy.

The MOS Structure Taxonomy and its application were discussed with personnel at the MOS Structure Branch, SSC-NCR, to confirm that the method is congruent with current practice.

Task Structure Taxonomy

The Task Structure Taxonomy classifies performance elements in MOS specifications in AR 611-201. It is used to confirm the MOS of direct operators and maintainers and to generate organized tasks lists for those MOS. The categories can be linked to training strategies that are useful in development of training.

The first step in development of the task structure was to select widely varied maintenance MOS, and obtain from AR 611-201 the narrative description of entry level duties for those MOS. These descriptions were cut up into individual statements, and sorted into clusters on the basis of similarity of performance required. Duplicate statements were eliminated. The clusters were organized into functions at higher levels than tasks. Fewer and fewer novel statements were encountered as functions were added. Based on these clusters, a taxonomy was formulated that classifies performance statements from AR 611-201.

Entry level narrative descriptions were extracted from AR 611-201 for seven MOS selected as representative of maintenance MOS (23T, 26K, 26L, 27F, 31J, 45L, and 63C). This sample was different from the one used in generating the taxonomy. Three raters (project staff) independently classified the narrative statements for each MOS specification, by making a check mark in each category represented. The raters were encouraged to check either general or specific categories or both, as appropriate.

The raters agreed most of the time, and discussed reasons for discrepancies; however, there was no formal scoring because the ratings were for formative evaluation. The maintenance taxonomy was revised to resolve ambiguities and to clarify the structure so that subsequent users could remember and readily locate categories for each statement.

Higher level categories reflected the form of statement in the MOS narrative. The most common form had an action verb and a direct object that designated equipment. Three kinds of modifiers were applied to the action verbs:

1. Enabling techniques, including tools, test equipment, printed job aids, and theory

2. Constraints, including safety practices and regulations

3. Performance level, specified as "assists,""performs," or "supervises"

The designation of "assists" at the entry level was not reflected in the taxonomy, because the soldier eventually is required to perform the action. The enabling techniques and constraints were often stated separately (e.g., "reads and understands technical manuals"). The occasion on which the action is performed was indicated in some cases.

The equipment was specified in three ways: generic (e.g., electronic equipment), components, or whole systems. The generic specification was used in the taxonomy to indicate type of equipment, but is insufficient to describe the role of equipment in task performance. The MOS Structure Taxonomy therefore, is needed in conjunction with the Task Structure Taxonomy.

Other forms of statements in AR 611-201 were:

1. Administrative tasks, including filling out standard forms and maintaining files

2. Supervisory tasks, such as scheduling of work assignments

The supervisory functions were confusing in the formative evaluation ratings, because the Task Structure Taxonomy was intended to cover only direct operation and maintenance. Statements from MOS specifications regarding supervisory functions were clustered by the content analysis method used for the MOS Structure Taxonomy and the resulting taxonomy is presented in Table 3-3. It is used with the MOS Structure Taxonomy (Table 3-1, Part 2) to identify related MOS.

An operator performance taxonomy, similar to the one for maintenance, was developed by the same process of content analysis, based upon specifications from AR 611-201 for the following MOS: 05B, 05C, 05D, 05K, 11B, 11H, 12F, 13B, 13C, 13E, 15D, 16D, 16E, 16F, 16P, 16S, 16T, 17B, 19D, 19K, 26Q, 26R, 31M, 31N, 31V, 32D, 36C, 36K, 72E, 72G, 72H, 74D, 93J, 98G, and 98J. This operator taxonomy was more elaborate than the one for maintainers. Two judges classified statements from the following MOS: 05H, 11B, 13B, 15E, 16R, 16T, 17K, 19E, 54C, 62E, 64C, and 93J. Their judgments were compared and discussed and the taxonomy was revised. The taxonomic categories were compared with those tasks listed in CODAP questionnaires for the following MOS: 16J, 15D, 93J, 16P, 15E, and 16D. Minor adjustments were made as a result. The operator and maintainer taxonomies were combined, resulting in the Task Structure Taxonomy shown in Table 3-2.

TABLE 3-1
MOS STRUCTURE TAXONOMY

Part 1: Direct Operators and Maintainers

Category	Title	MOS	Page in AR 611-201	Functions a/				
				Operate	Maintain			
				O	S	(DS	GS	D)
1.1	Aviation							
1.1.1	Aircraft							
1.1.1.1	Operator (Officer and Warrant Officer (WO))							
1.1.1.2	Maintenance							
1.1.1.2.1	By Type Aircraft							
	Utility Helicopter Repairer	67N	3-67-9	X	X	X	X	X
	Utility/Cargo Airplane Repairer	67G	3-67-5	X				
	Observation/Scout Helicopter Repairer	67V	3-67-7	X	X	X	X	X
	Tactical Transport Helicopter Repairer	67T	3-67-39	X	X	X	X	X
	Attack Helicopter Repairer	67Y	3-67-11	X	X	X	X	X
	Medium Helicopter Repairer	67U	3-67-19	X	X	X	X	X
	Heavy Lift Helicopter Repairer	67X	3-67-15	X	X	X	X	X
	Observation Airplane Repairer	67H	3-67-41					X
1.1.1.2.2	By Aircraft Component b/							
	Aircraft Weapon Systems	68M	3-67-37		X			
	Aircraft Fire Control Repairer	68J	3-67-35		X			
	Aircraft Power Plant Repairer	68B	3-67-21		X			
	Aircraft Powertrain Repairer	68D	3-67-23		X	X	X	X
	Aircraft Electrician	68F	3-67-25		X	X	X	X
	Aircraft Structural Repairer	68G	3-67-27		X	X	X	X
	Aircraft Pneudraulics Repairer	68H	3-67-31		X	X	X	X

a/ Maintenance column headings: O = Organizational maintenance, S = Support, DS = Direct Support, GS = General Support, D = Depot. Support level maintenance (S) implies DS and GS, and sometimes depot maintenance.

b/ Aircraft component repairers were classified as support level personnel, even though this generally was not explicit in the MOS specification.

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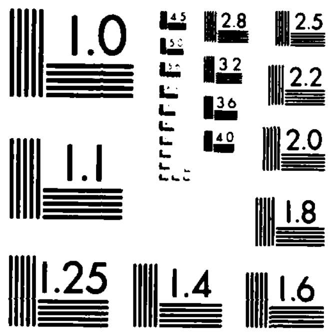

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TABLE 3-1
MOS STRUCTURE TAXONOMY

Part 1: Direct Operators and Maintainers (Continued)

Category	Title	MOS	Page in AR 611-201	Functions: Operate	Maintain: O	S	(DS	GS	D)
1.1.2	Associated Equipment								
1.1.2.1	Ground Control Equipment a/								
	ATC Radar Controller	93J	3-64-47	X					
	Ground Controlled Approach Radar Repairer	26D	3-28-5		X	X			X
1.1.2.2	On Board Equipment								
1.1.2.2.1	Sensors								
	Aerial Electronic Warning Defense Equipment Repairer	26K	3-28-35		X	X	X	X	X
	Aerial Photoactive Sensor Repairer	26F	3-28-35			X	X	X	X
	Aerial Surviellance Sensor Repairer	26E	3-28-9			X	X	X	X
	Aerial Sensor Specialist (OV-ID) Operator	96H	3-96-23	X					
1.1.2.2.2	Avionics								
	Avionic Mechanic	35K	3-38-23		X	X	X	X	
	Avionic Communication Equipment Repairer	35L	3-28-25			X	X	X	X
	Avionic Navigation and Flight Control Equipment Repairer	35M	3-28-27		X	X	X	X	
	Avionic Special Equipment Repairer	35R	3-28-31		X	X	X	X	
1.2	Artillery/Ballistic/Land Combat Missile Systems								

a/ MOS associated with radar that are not components of specific systems are classified functionally under Aviation (air traffic control), Field Artillery (target acquisition), and Air Defense (AD Radar). Miscellaneous radars are classified under Electronic Sensors (Radar).

TABLE 3-1
MOS STRUCTURE TAXONOMY

Part 1: Direct Operators and Maintainers (Continued)

Category	Title	MOS	Page in AR 611-201	Functions: Operate	Maintain: O	S	(DS	GS	D)
1.2.1	Specific Systems								
	PERSHING Missile Crewmember	15E	3-13-9	X					
	PERSHING Electronics Material Specialist	21G	3-27-5		X				
	PERSHING Electronics Repairer	21L	3-27-7			X			
	PERSHING Electrical Mechanical Repairer	46N	3-27-9			X	X	X	
	Multiple Launch Rocket Systems Crewmember	13M	3-13-41	X					
	MLRS Repairer	27M	3-27-33		X				
	MLRS/LANCE Operation/Fire Direction Specialist	15J	3-13-23	X					
	Land Combat Support System Test Specialist/LANCE Repairer	27B	3-27-11		X		X	X	X
	LANCE Missile Crewmember	15D	3-13-17	X					
1.2.2	FA Target Acquisition a/								
	Field Artillery Target Acquisition Specialist	17C	3-13-27	X					
	Field Artillery Radar Crewmember	17B	3-13-25	X					
	Field Artillery Firefinder	13R	3-13-39	X					
	Field Artillery Meteorological Crewmember	93F	3-13-31	X					
	TACFIRE Operations Specialist	13C	3-13-35	X					
	Tactical Fire Control Systems Repairer	45G	3-63-81			X	X	X	
	Cannon Fire Direction Specialist	13E	3-13-7	X					
	Field Artillery Computer Repairer b/	34Y	3-74-33			X	X	X	X

a/ MOS associated with radar that are not components of specific systems are classified functionally under Aviation (air traffic control), Field Artillery (target acquisition), and Air Defense (AD Radar). Miscellaneous radars are covered under Electronic Sensor (Radar).

b/ Fire control computers for both Armor and Artillery maintained by 34Y (FA, Target Acquistion).

TABLE 3-1
MOS STRUCTURE TAXONOMY

Part 1: Direct Operators and Maintainers (Continued)

Category	Title	MOS	Page in AR 611-201	Functions: Operate	Maintain: O	S	(DS	GS	D)
1.2.3	Cannon								
	Cannon Crewman	13B	3-13-5	X					
	Fire Control Instrument Repairer c/	41C	3-63-43			X	X	X	
	Artillery Repairer	45L	3-68-49			X			
	Self-Propelled Field Artillery Turret Mechanic	45D	3-63-55		X				
	Self-Propelled Field Artillery System Mechanic	63D			X				
1.3	Armor b/ c/								
	SHILLELAGH Repairer	27H	3-27-21			X	X	X	
	M48-M60 Armor Crewman	19E	3-19-7	X					
	M60A1/A3 Tank System Mechanic	63N	3-68-67		X				
	M60 Tank Turret Mechanic	46N	3-63-65		X				
	Tank Turret Repairer	45K	3-63-47			X	X	X	
	M60 A2 Tank System Mechanic	63R			X				
	M60 A2 Tank Turret Mechanic	45R			X				
	M1 Abrams Tank Turret Mechanic	45E	3-63-59		X				
	M1 Abrams Tank Systems Mechanic	63E	3-63-61		X				
	M1 Abrams Armor Crewman	19K	3-19-21	X					

b/ Fire control computers for both Armor and Artillery maintained by 34Y (FA, Target Acquisition).

c/ Fire control instrument repairer (41C) maintains for Armor as well as FA cannon.

TABLE 3-1
MOS STRUCTURE TAXONOMY

Part 1: Direct Operators and Maintainers (Continued)

Category	Title	MOS	Page in AR 611-201	Functions: Operate	Maintain: O	S	(DS	GS	D)
1.4	Infantry								
	Infantryman d/	11B	3-11-5	X					
	Indirect Fire Infantryman	11C	3-11-9	X					
	Fighting Vehicle Infantryman	11M	3-11-13	X					
	Cavalry Scout d/	19D	3-19-5	X					
	Improved TOW Vehicle/Infantry Fighting Vehicle/Cavalry Fighting Vehicle Turret Mechanic	45T	3-63-75		X				
	Improved TOW Vehicle/Infantry Fighting Vehicle/Cavalry Fighting Vehicle System Mechanic	63T	3-63-77		X				
	Heavy Anti-Armor Weapons Infantryman	11H	2-11-11	X					
	TOW/DRAGON Repairer	27E	3-27-15						
1.5	Air Defense								
1.5.1	Light AD Systems								
	VULCAN Repairer	27F	3-27-9				X	X	X
	VULCAN System Mechanic	24M	3-27-25		X				
	ADA Short Range Gunnery Crewman	16R	3-16-19	X					
	ADA Short Range Missile Crewman	16P	3-16-15	X					
	CHAPARRAL System Mechanic	24N	3-27-27	X					
	CHAPARRAL/REDEYE Repairer	27G	3-27-19				X	X	X
	MANPADS Crewman	16S	3-16-25	X					

d/ Cavalry Scout is listed under Infantry because of similarity of duties, and tasks, even though it is part of Armor CMF.

TABLE 3-1
MOS STRUCTURE TAXONOMY

Part 1: Direct Operators and Maintainers (Continued)

Category	Title	MOS	Page in AR 611-201	Functions: Operate	Maintain: O	S	(DS	GS	D)
1.5.2	AD Radar (Separate from Systems) a/								
	Defense Acquisition Radar Operator	16J	3-16-23	X					
	Defense Acquistion Radar Mechanic	24P	3-23-21		X				
	Air Defense Radar Repairer	26H	3-23-13			X	X	X	X
	Forward Area Alerting Radar Repairer	27N	3-27-31			X	X	X	
1.5.3	AD Command and Control Systems								
	AN/TSQ-73 Air Defense Artillery Command & Control System Operator Repairer	25L	3-23-71	X	X				
	Operations Central Repairer (AN/TSQ-38)	25J	3-23-59		X	X	X	X	

a/ Radars associated with specific functions but not specific systems are for Aviation (air traffic control). Field Artillery (target acquisition), and Air Defense (AD Radar). Miscellaneous radars are covered under Electronic Sensor (Radar).

TABLE 3-1
MOS STRUCTURE TAXONOMY

Part I: Direct Operators and Maintainers (Continued)

Category	Title	MOS	Page in AR 611-201	Functions: Operate	Maintain (O	S	(DS	GS	D)
1.5.4	AD Missile Systems								
	PATRIOT Missile Crewmenber	16T	3-16-27	X					
	PATRIOT Operator and System Mechanic	24T	3-23-73	X	X				
	ROLAND Crewmember	16G	3-16-29	X					
	ROLAND Mechanic	24S	3-27-31			X	X	X	
	ROLAND FMTS Repairer	27D	3-27-35			X	X	X	
	ROLAND Repairer	27C	3-27-33		X				
	HAWK Missile Crewmember	16D	3-16-11	X					
	HAWK Fire Control Crewmember	16E	3-16-13	X					
	Improved HAWK Firing Section Mechanic	24C	3-23-39		X				
	Improved HAWK Information Coordination Central Mechanic	24G	3-23-41		X				
	Improved HAWK Fire Control Mechanic	24E	3-23-43			X	X	X	
	Improved HAWK Pulse Radar Repairer	24J	3-23-47			X	X	X	
	Improved HAWK Fire Control Repairer	24H	3-23-45			X	X	X	
	Improved HAWK Launcher/Mechanical Systems Repairer	24L	3-23-51			X	X	X	
	Improved HAWK Fire Continuous Wave Radar Repairman	24K	3-23-49			X	X	X	
	Improved HAWK Maintenance Chief	24V	3-23-53			X	X	X	
	Improved HAWK Master Mechanic	24R	3-25-75		X				
	HERCULES Fire Control Crewmember	16C	3-16-9	X					
	HERCULES Missile Crewmember	16B	3-16-7	X					
	NIKE HERCULES Fire Control Mechanic	24Q	3-23-17					X	
	HERCULES Electronics Mechanic	24U	3-23-19					X	
	NIKE HERCULES Missile Launcher Repairer	22N	3-23-7			X	X	X	
	NIKE High Power Radar-Simulator Repairer	23U	3-23-11			X	X	X	
	NIKE Track Radar Repairer	23N	3-23-9			X	X	X	
	NIKE Test Equipment Repairer	22L	3-23-5		X	X	X	X	
	NIKE Maintenance Chief	23W	3-23-15			X	X	X	

TABLE 3-1
MOS STRUCTURE TAXONOMY

Part 1: Direct Operators and Maintainers (Continued)

Category	Title	MOS	Page in AR 611-201	Functions: Operate	Maintain: O	S	(DS	GS	D)
1.6	Electronic Sensors (Excluding AD, Airborne Systems)								
1.6.1	Radar a/								
	Ground Surveillance Radar Crewman	17K	3-96-31	X					
	Weapons Support Radar Repairer	63W	3-29-5		X	X	X	X	X
	Combat Area Surveillance Radar Repairman	26C	3-29-71		X	X	X	X	X
1.6.2	EW/SIGINT								
	EW/SIGINT Emitter Identifier/Locater	05D	3-98-7	X					
	EW/SIGINT Morse Interceptor	05H	3-98-5	X					
	EW/SIGINT Noncommunications Interceptor	98J	3-98-19	X					
	EW/SIGINT Non-Morse Interceptor	05K	3-98-11	X					
	EW/SIGINT Voice Interceptor	98G	3-98-21	X					
	EW/Intercept Systems Repairer	33S	3-33-53	X					
1.6.3	Other Sensors								
	Unattended Ground Sensor Specialist	17H	3-96-35	X					
1.7	Communication								

a/ MOS associated radars that are not components of specific systems are classified under the function they serve. Therfore, see also Aviation (air traffic control), Field Artillery (target acquisition), and Air Defense (AD Radar). Miscellaneous radars are covered under Electronic Sensors (Radar).

TABLE 3-1
MOS STRUCTURE TAXONOMY

Part 1: Direct Operators and Maintainers (Continued)

Category	Title	MOS	Page in AR 611-201	Functions: Operate	Maintain: O	S	(DS	GS	D)
1.7.1	Operator/Installer								
	Radio Operator	05B	3-31-5	X					
	Tactical Wire Operations Specialist	36K	3-31-45	X					
	Wire Systems Installer/Operator	36C	3-31-27	X					
	Data Communications Switching Center Specialist	72G	3-31-53	X					
	Telecommunications Center Operator	72E	3-31-47	X					
	Strategic Satellite Microwave Systems Operator	26R	3-31-13	X					
	Tactical Satellite/Microwave Systems Operator	26Q	3-31-9	X					
	Multichannel Communications Equipment Operator	31M	3-31-17	X					
	Radio Teletype Operator	05C	3-31-7	X					
	Station Technical Controller	32D	3-31-33	X					
	Tactical Circuit Controller	31N	3-31-21	X					
	Tactical Communications Systems Operator Mechanic	31V	3-31-25	X	X				
	Central Office Operations Operator	72H	3-31-57	X					
1.7.2	Maintenance								
1.7.2.1	Component Repairer								
	Field Radio Repairer	31E	3-29-23			X	X	X	X

TABLE 3-1
MOS STRUCTURE TAXONOMY

Part 1: Direct Operators and Maintainers (Continued)

Category	Title	MOS	Page in AR 611-201	Functions: Operate	Maintain: O	S	(DS	GS	D)
1.7.2.2	Systems Repairer								
	SATCOM Equipment Repairer	26Y	3-29-19	X	X	X	X	X	X
	Fixed Ciphony Repairer	32F	3-29-29		X	X	X	X	
	Fixed Cryptographic Equipment Repairer	32G	3-29-43						
	Fixed Station Radio Repairer	32H	3-29-47		X	X	X	X	
	Teletypewriter Repairer	31J	3-19-27		X	X	X	X	X
	Electronic Switching Systems Repairer	36L	3-29-67						
	Dial/Manual Central Office Repairer	36H	3-29-63		X	X	X	X	X
	Field General COMSEC Repairer	31S	3-29-31		X	X	X	X	
	Field Systems COMSEC Repairer	31T	3-29-35			X	X	X	
	Strategic Microwave Systems Repairer	26V	3-29-15			X	X	X	X
	Tactical Microwave Systems Repairer	26L	3-29-11			X	X	X	X
	Antenna Installer Specialist	36D	3-31-41		X	X	X	X	
	Cable Splicer	36E	3-31-43	X					
1.8	Engineering (Combat, General and Topographic)	e/							
	Engineer Tracked Vehicle Crewman (Combat)	12F	3-12-23	X					
	Track Vehicle Mechanic	63Y	3-63-37		X				
	Track Vehicle Repairer	63H	3-63-23				X	X	X
	Heavy Construction Equipment Operator	62E	3-51-45	X					
	Lifting and Loading Equipment Operator	62F	3-51-47	X					
	Quarrying Specialist	62G	3-51-37	X					
	Concrete And Asphalt Equipment Operator	62H	3-51-39	X					
	General Construction Equipment Operator	62J	3-51-41	X					
	Construction Equipment Repairer Specialist	62B	3-63-15		X	X	X	X	
	Topographic Instrument Repair Specialist	41B	3-81-5		X	X	X	X	X

e/ Fuel and electrical systems for engineering vehicles are maintained by 63G, under transporation.

TABLE 3-1
MOS STRUCTURE TAXONOMY

Part 1: Direct Operators and Maintainers (Continued)

Category	Title	MOS	Page in AR 611-201	Functions: Operate	Maintain: O	S	(DS	GS	D)
1.9	Transportation and power generation maintenance								
1.9.1	Ground transport, generators								
	Motor Transport Operator	64C	3-64-5	X					
	Light Wheel Vehicle/Power Generation f/ Mechanic	63B	3-63-33		X				
	Heavy Wheel Vehicle Mechanic	63S	3-63-31		X				
	Wheel Vehicle Repairer	63W	3-63-21				X	X	X
	Fuel and Electrical Systems Repairer e/ f/	63G	3-63-27				X	X	X
	Power Generation Equipment Repairer f/	52D	3-62-19				X	X	X
1.9.2	Marine Transport								
	Watercraft Operator	61B	3-64-13	X					
	Marine Hull Repairer	61F	3-64-21						
	Watercraft Engineer	61C	3-64-17		X	X	X	X	
1.10	Special Support Factors								
1.10.1	Utilities								
	Utilities Equipment Repairer	52C	3-63-13		X	X	X	X	
1.10.2	Power Generation f/ (see 1.9.1)								
1.10.3	Instrument Maintenance								
	Electronic Instrument Repairer	35B	3-29-55			X	X	X	
	Calibration Specialist	35H	3-29-59						
	Special Electronic Devices Repairer	35H	3-29-57		X	X	X	X	
	Automatic Test Equipment Repairer	35C	3-39-71		X	X	X	X	

e/ Fuel and electrical systems for engineering vehicles are maintained by 63G, under transportation. "Power Generation" is included as a functional category here only to ensure reference to the other category when appropriate.

f/ Tactical power generators are maintained by MOS 63B, 52D, and 63G listed under transportation.

TABLE 3-1
MOS STRUCTURE TAXONOMY

Part 1: Direct Operators and Maintainers (Continued)

Category	Title	MOS	Page in AR 611-201	Functions: Operate	Maintain: O	S	(DS	GS	D)
1.10.4	Ammunition								
1.10.5	Fuel (Petroleum)								
1.10.6	Data Processing, Computers & Office Machines								
1.10.6.1	Operators								
	Computer/Machine Operator	74D	3-74-7	X					
1.10.6.2	Maintenance								
	DSTE Repairer	34F	3-74-23			X	X	X	
	Punchcard Machine Repairer	34B	3-74-19		X	X	X	X	
	Office Machine Repairer	41J	3-63-5			X	X	X	
	Decentralized Automated Service Support Computer Repairer	34C	3-74-31		X	X	X	X	
	ADMSE Repairer	34H	3-74-29			X	X	X	
	IBM 360 Repairer	34K	3-74-27			X	X	X	
	NCR 500 Computer Repairer	34E	3-74-21			X	X	X	
1.10.7	Chemical								
	Smoke Operations Specialist	54C	3-54-5	X	X				
	NBC Specialist	54E	3-54-75	X	X				
1.10.8	Miscellaneous Maintenance (used by many branches)								
	Metal Worker	44B	3-63-77						
	Machinist	44E	3-63-9						
	Small Arms Repairer	45B	3-63-45			X			
	Quartermaster & Chemical Equipment Repairer	63J	3-63-29		X	X	X	X	
1.10.9	Material Logistics								
1.10.10	Intelligence								
1.11	General Supervisors								

TABLE 3-1
MOS STRUCTURE TAXONOMY

Part 2: Associated Functions (MOS) g/

Category	Title	MOS	Page in AR 611-201
2.1	Aviation h/		
2.1.1	AIRCRAFT		
2.1.1.2	Maintenance		
	Aircraft Maintenance Senior Sergeant	67Z	3-67-13
	Aircraft Quality Supervisor	67W	3-67-13
2.1.1.2.1	By Type		
2.1.1.2.2	By Component		
	Aircraft Components Repair Supervisor	68K	3-67-33
2.1.2.1	Ground Control Equipment		
	Air Traffic Control (ATC) Tower Operator	93H	3-64-45
	Meteorological Observer	93E	3-64-9
	Flight Operations Coordinator	71P	3-64-43
2.1.2.2	On Board Equipment		
	Parachute Rigger	43E	3-76-27
2.1.2.2.1	Sensors		
2.1.2.2.2	Avionics		
	Avionic Equipment Maintenance Supervisor	35P	3-28-29
2.2	Artillery		
	Field Artillery Senior Sergeant	13Z	3-13-13
2.2.1	Specific Systems		
	Cannon/Missile Senior Sergeant	13Y	3-13-11
2.2.2	FA Target Acquisition		
	Field Artillery Target Acquisition Senior Sergeant	13W	3-13-9
	Fire Support Specialist	13F	3-13-33
	Field Artillery Surveyor	82C	3-13-29
2.2.3	Cannon		
2.2.3.1	Weapon System		
	Armament/Fire Control Maintenance Supervisor	45Z	3-63-52
2.2.3.2	Vehicle Maintenance		
2.3	Armor		
	Armor Senior Sergeant	19Z	3-19-11
2.4	Infantry		
2.4.1	Fighting Vehicle		
2.4.2	No Vehicle		
2.5	Air Defense		
	Ballistic/Land Combat/Light Air Defense Systems Maintenance Chief	27Z	3-27-29
	Air Defense Artilery Senior Sergeant	16Z	3-16-5
	ADA Operations and Intelligence Assistant	16H	3-16-21

g/ Numbering of sections corresponds with Part 1.

h/ Air Transport functions are coordinated by transportation personnel.

TABLE 3-1
MOS STRUCTURE TAXONOMY

Part 2: Associated Functions (MOS) (Continued)

Category	Title	MOS	Page in AR 611-201
2.5.1	Light AD Systems		
2.5.2	AD Radar (separate from systems)		
2.5.3	AD Command and Control Systems		
2.6	Electronic Sensors (excluding AD)		
2.6.1	Radar		
2.6.2	EW/SIGINT		
	EW/SIGINT Chief	98Z	3-98-25
	EW/SIGINT Analyst	98C	3-98-17
2.6.3	Other Sensors		
2.7	Communication		
	Communications-Electronics Operations Chief	31Z	3-31-29
2.7.1	Operator/Installer		
	Signal Security Specialist	05G	3-98-13
2.7.2	Maintenance		
2.8	Engineering		
2.8.1	Combat Engineering		
	Atomic Demolition Munitions Specialist	12E	3-12-17
	Combat Engineer	12B	3-12-5
	Bridge Crewman	12C	3-12-11
	Combat Engineering Senior Sergeant	12X	3-12-21
2.8.2	General Engineering		
	General Engineering Supervisor	51Z	3-51-23
2.8.2.1	Construction Engineering		
	Construction Engineering Supervisor	51H	3-51-31
	Construction Equipment Supervisor	62N	3-51-43
	Plumber	51K	3-51-51
	Electrician	51R	3-51-15
	Construction Surveyor	82B	3-51-7
	Carpentry and Masonry Specialist	51B	3-51-29
	Structures Specialist	51C	3-51-33
2.8.2.2	Technical Engineering		
	Technical Engineering Supervisor	51T	3-51-9
	Material Quality Specialist	51G	3-51-5
	Technical Drafting Specialist	81B	3-51-11
	Construction Supervisor	82B	
2.8.2.3	Power Engineering		
	Transmission and Distribution Specialist	52G	3-51-53
	Prime Power Production Specialist	52E	3-51-13
2.8.2.4	Specialty Engineering		
	Water Treatment and Plumbing Systems Specialist	51N	3-51-19
	Firefighter	51M	3-51-25
	Diver	52E	

TABLE 3-1
MOS STRUCTURE TAXONOMY

Part 2: Associated Functions (MOS) (Continued)

Category	Title	MOS	Page in AR 611-201
2.8.3	Topographic Engineering		
	Photo and Layout Specialist	83E	3-81-21
	Photolithographer	83F	3-81-17
	Topographic Engineering Supervisor	81Z	3-81-15
	Topographic Surveyor	82D	3-81-7
	Cartographer	81C	3-81-11
2.9	Transportation h/		
	Cargo Specialist	57H	3-64-9
2.9.1	Surface Operations		
	Transportation Senior Sergeant	64Z	3-64-11
	Traffic Management Coordinator	71N	3-64-7
2.9.2	Marine Operations		
	Marine Senior Sergeant	61Z	3-64-23
2.10	Special Support Factors		
2.10.1	Utilities		
2.10.2	Power Generation		
2.10.3	Instrument Maintenance		
2.10.4	Ammunition		
	Ammunition Supervisor	55Z	3-66-17
2.10.4.1	Nuclear		
	Nuclear Weapons Maintenance Specialist	55G	3-55-13
	Nuclear Weapons Electronics Specialist	35F	3-55-19
2.10.4.2	Conventional		
2.10.4.2.1	Disposal		
	Explosive Ordinance Disposal Specialist	55D	3-55-9
2.10.4.2.2	Supply and Accounting		
	Ammunition Inspector	55X	3-55-15
	Ammunition Stock Control & Accounting Specialist	55R	3-55-21
	Ammunition Specialist	55B	3-55-5
2.10.5	Fuel (petroleum)		
	Petroleum Laboratory Specialist	92C	3-92-11
	Petroleum Supply Specialist	76W	3-92-5
2.10.6	Data Processing, Computer, and Office Machines		
	Data Processing NCO	74Z	3-74-15
	Programmer/Analyst	74F	3-74-11
2.10.6.1	Operators		
2.10.6.2	Maintenance		
	ADP Maintenance Supervisor	34Z	3-74-17
2.10.7	Chemical		
	Chemical Senior Sergeant	54Z	3-54-13
	Chemical Laboratory Specialist	92D	3-54-11
2.10.8	Miscellaneous Maintenance		

h/ Air transport functions are coordinated by transporation personnel.

TABLE 3-1
MOS STRUCTURE TAXONOMY

Part 2: Associated Functions (MOS) (Continued)

Category	Title	MOS	Page in AR 611-201
2.10.9	Material Logistics		
	Material Control and Accounting Specialist	76P	3-76-13
2.10.10	Intelligence		
	Counterintelligence Agent	97B	3-96-5
	Interrogator	96C	3-96-9
	Image Interpreter	96D	3-96-17
	Area Intelligence Specialist	97C	3-96-37
	Intelligence Analyst	96B	3-96-13
	Intelligence Senior Sergeant	96Z	3-96-21
2.11	General Supervisors		
	Communications-Electronics Maintenance Chief	32Z	3-29-51
	Mechanical Maintenance Supervisor	63Z	3-63-39
	Senior Supply Sergeant	76Z	3-76-26.3

TABLE 3-1
MOS STRUCTURE TAXONOMY

Part 3: Not Related to Categories of Equipment and Reserve Forces

Category	Title	MOS	Page in AR 611-201
3.1	Administrative		
3.1.1	General Purpose		
	Secretary	71C	3-71-7
3.1.2	Specific Functions		
3.1.2.1	Finance		
	Finance Senior Sergeant	73Z	3-71-37
	Finance Specialist	73C	3-71-31
	Accounting Specialist	73D	3-71-35
3.1.2.2	Legal		
	Legal Clerk	71D	3-71-39
	Court Reporter	73C	3-71-43
3.1.2.3	Other		
	Equal Opportunity NCO	00U	3-71-47
	Chapel Activities Specialist	71M	3-71-15
	Administrative Specialist	71L	3-71-9
	Physical Activity Specialist	03C	3-71-5
	Correctional Specialist	95C	3-95-11
	Graves Registratio Specialist	57F	3-76-35
3.2	Personnel		
	Personnel Actions Specialist	75E	3-71-25
	Personnel Administration Specialist	75B	3-71-19
	Personnel Information System Management Specialist	75F	3-71-49
	Personnel Management Specialist	75C	3-71-21
	Personnel Records Specialist	75D	3-71-23
	Personnel Sergeant	75Z	3-71-27
3.3	Service		
	Food Service Specialist	94B	3-94-5
	Military Police	95B	3-95-5
	Club Manager	00J	3-71-45
	Fabric Repair Specialist	43M	3-76-31
	Laundry and Bath Specialist	57E	3-76-33
	Unit Supply Specialist	76Y	3-76-25
	Subsistence Supply Specialist	76X	3-76-21
3.4	Special Status		
	Command Sergeant Major	00Z	1-10
	Commissioned Officer Candidate	09S	14-1
	Warrant Officer Candidate	09W	14-1
	College Trainee	09C	14-1
	Recruiter	00E	3-79-5
	Reenlistment NCO	79D	3-95-9
	Special Duty Assignment	00D	14-1
	Special Agent	95D	3-95-15

TABLE 3-1
MOS STRUCTURE TAXONOMY

Part 3: Not Related to Categories to Equipment and Reserve Forces

Category	Title	MOS	Page in AR 611-201
3.5	Medical		
	Psychiatric Specialist	91F	3-19-19
	Environmental Health Specialist	91S	3-91-53
	Operating Room Specialist	91D	3-91-15
	Cardiac Specialist	91N	3-91-35
	Optical Laboratory Specialist	42E	3-91-61
	Clinical Specialist	91C	3-91-11
	ENT Specialist	91U	3-91-37
	Nuclear Medicine Specialist	91W	3-91-43
	Animal Care Specialist	91T	3-91-56.2
	Orthopedic Specialist	91H	3-91-23
	Eye Specialist	91Y	3-91-39
	Dental Laboratory Specialist	42D	3-91-5
	Dental Specialist	91E	3-91-7
	Occupational Therapy Specialist	91L	3-91-33
	Patient Administration Specialist	71G	3-91-63
	Veterinary Specialist	91R	3-91-57
	Behavioral Sciences Specialist	91G	3-91-21
	Biological Sciences Assistant	01H	3-91-79
	Biomedical Equipment Specialist, Basic	35G	3-91-67
	Biomedical Equipment Specialist, Advanced	35U	3-91-77
	X-Ray Specialist	91P	3-91-45
	Physical Therapy Specialist	91F	3-91-31
	Cytology Specialist	92E	3-91-81
	Orthopedic Specialist	42C	3-91-25
	Respiratory Specialist	91V	3-91-41
	Pharmacy Specialist	91Q	3-91-47
	Hospital Food Service Specialist	94F	3-91-9
	Medical Laboratory Specialist	92B	3-91-49
	Medical Specialist	91B	3-91-27
	Practical Nurse	91C	3-91-11
	Medical Supply Specialist	76J	3-76-5
3.6	Public Affairs and Audio Visual		
	Audio TV Specialist	84F	3-84-19
	Audio-Visual Equipment Repairer	41K	3-84-7
	Journalist	71Q	3-84-9
	Broadcast Journalist	71R	3-84-11
	Public Affairs/Audiovisual Chief	84Z	3-84-23
	Radio/Television Systems Specialist	26T	3-84-5
	Motion Picture Specialist	84C	3-84-17
	Illustrator	81E	3-84-13
	TV/Radio Broadcast Operations Chief	84T	3-84-21
	Still Photographic Specialist	84B	3-84-15

TABLE 3-1
MOS STRUCTURE TAXONOMY

Part 3: Not Related to Categories to Equipment and Reserve Forces

Category	Title	MOS	Page in AR 611-201
3.7	Band		
	Woodwind Group Leader	02Q	3-97-15
	Percussion Player	02M	3-97-7
	Oboe Player	02H	3-97-7
	Trombone Player	02E	3-97-7
	Tuba Player	02F	3-97-9
	Saxophone Player	02L	3-97-7
	Enlisted Band Leader	02Z	3-97-17
	Special Bandperson	02S	3-97-19
	French Horn Player	02D	3-97-7
	Cornet or Trumpet Player	02B	3-97-7
	Percussion Group Leader	02R	3-97-15
	Clarinet Player	02J	3-97-7
	Piano Player	02N	3-97-11
	Guitar Player	02T	3-97-13
	Baritone or Euphonium Player	02C	3-97-7
	Basson Player	02K	3-97-7
	Brass Group Leader	02P	3-97-15
	Flute or Piccolo Player	02G	3-97-7
3.8	Reserve Forces MOS		
	Railway Car Repairer (RESERVE FORCES)	65D	3-64-29
	Railway Movement Coordinator (RESERVE FORCES)	65K	3-64-39
	Locomotive Electrician (RESERVE FORCES)	65F	3-64-27
	Locomotive Operator (RESERVE FORCES)	65H	3-64-35
	Locomotive Repairer (RESERVE FORCES)	65B	3-64-25
	Aerial Sensor Specialist (OV-IB/C/RESERVE FORCES)	17L	3-96-27
	Aerial Surveillance Photographic Equipment Repairer (RESERVE FORCES)	41G	3-28-33
	Railway Senior Sergeant (RESERVE FORCES)	65Z	3-64-41
	Aerial Surveillance Infrared Repairer (RESERVE FORCES)	26N	3-28-21
	UNIVAC 1004-1005, DCT 9000 System Repairer	34J	3-74-25
	Railway Section Repairer (RESERVE FORCES)	65G	3-64-33
	Industrial Gas Production Specialist (RESERVE FORCES)	53B	3-51-49
	Card and Tape Writer (RESERVE FORCES)	74B	3-74-5
	Light Air Defense Artillery Crewman (RESERVE FORCES)	16F	3-16-17
	Train Crew Member (RESERVE FORCES)	65J	3-64-37
	Airbrake Repairer (RESERVE FORCES)	65E	3-64-31
	Aerial Surveillance Radar Repairer (RESERVE FORCES)	26M	3-28-7

TABLE 3-2
TASK STRUCTURE TAXONOMY

Part I: Common Soldiers Tasks (Excluding firing weapons and communications)*

CATEGORIES	EXAMPLES
I. Construction	
A. Individual positions	Constructs individual fighting positions.
B. Unit positions	UNIT DEFENSE. Constructs fortifications, bunkers, and crew-served weapons emplacements.
C. Cover and concealment	Employs principles of cover, concealment, and camouflage.
D. Breaching, Bridging, Demolition	Assists in breaching minefields and obstacles.
II. Other Unit Functions	
A. Guard duty, Security	Performs outpost and security guard duties, using passwords and countersign.
B. Miscellaneous tasks	Performs drill and ceremonies and other post, camp and station duties as required.
III. Patrol	
A. Movement techniques	Employs proper dismounted movement techniques as part of a dismount team.
B. Land Navigation	LAND NAVIGATION. Locates points on map, distinguishes topographic features, and uses compass.

TABLE 3-2
TASK STRUCTURE TAXONOMY

Part I: Common Soldiers Tasks (Excluding firing weapons and communications) (Continued)

CATEGORIES	EXAMPLES
C. Reconnaissance	
1. Gathering information	Collects and reports tactical information as a member of combat or reconnaissance patrol.
2. Taking prisoners	Captures prisoners. Renders verbal reports on activities.
IV. Battlefield Survival	
A. Protection from contaminants (NBC)	Protects self, weapons and equipment from chemical and other contaminants.
B. First Aid sanitation	Administers first aid and applies field sanitation methods.
C. Physical readiness	Insures highest state of physical readiness at all times.

TABLE 3-2
TASK STRUCTURE TAXONOMY

Part 2: Operation of Systems

Section A: Primary Functions (Vehicle operation, target engagement, and communication)

CATEGORIES	EXAMPLES
I. Vehicle Operation	
A. Watercraft operation	
B. Driving (land vehicles)	
1. Tactical driving (against threat)	DRIVING. Operates Infantry Fighting Vehicle (IFV) over varied terrain...
a. Selecting routes, firing positions.	Selects routes and defilade firing positions.
b. Driving during target *engagement*.	Provides a steady platform for stabilized *weapons fire*.
2. Transportation of people, equipment	
a. *Loading*	*Loads/lashes cargo and equipment onto* vehicles and unloads from vehicles.
b. Transport	Transports personnel, supplies and equipment, and weapons and small arms ammunition in vehicles.
3. Guidance	
a. Visual signals	Uses and responds to visual signals.
b. Land navigation	Maintains orientation in moving vehicle by comparing terrain with map.

TABLE 3-2
TASK STRUCTURE TAXONOMY

Part 2: Operation of Systems

Section A: Primary Functions (Vehicle operation, target engagement, and communication) (continued)

CATEGORIES	EXAMPLES
4. Operating ancillary equipment	Operates special purpose equipment such as bridge launching/retrieving mechanisms, lifting devices, power winches, and bulldozer moldboards.
5. Servicing operations	
a. Pre/post inspection, operator maintenance	Performs before/during/after operation and scheduled vehicle services.
b. Refueling	Assists in refueling and vehicle recovery operations.
c. Recovery	Assists in recovery operations for light wheeled and tracked vehicles.
II. Preparing system for operation (weapons or communication)	
A. Putting system in place	
1. Installation	Performs cabling and equipment installation and removal.
2. March order and emplacement	Performs march order and emplacement of the launchers and associated equipment.

TABLE 3-2
TASK STRUCTURE TAXONOMY

Part 2: Operation of Systems

Section A: Primary Functions (Vehicle operation, target engagement, and communication) (Continued)

CATEGORIES	EXAMPLES
B. Putting system into operation (not in context of installation or emplacement).	
1. Weapons and ammunition	
a. Ammunition	
(1) Missiles	Perform missile loading and unloading duties. Assists in canning and decanning and assembly of missile.
(2) Conventional rounds	Secures, prepares, and stows ammunition for IFV turret weapons. Applies safety procedures in handling ammunition, fuses and charges.
b. Adjusting weapon tube, sights	Assists in boresighting and zeroing the 25mm Automatic Cannon...
2. Preparing plans	
a. Compiling, posting, plotting of firing data	Prepares range cards.
b. Planning unit operations	(preparing OPORDERS, SITREP, other plans)

TABLE 3-2
TASK STRUCTURE TAXONOMY

Part 2: Operation of Systems

Section A: Primary Functions (Vehicle operation, target engagement, and communication) (Continued)

CATEGORIES	EXAMPLES
3. Activating command station (including FDC's, and control station for electronic equipment)	
a. Adjusting electronic equipment	
(1) Computers	Prepares battery computer unit for operation.
(2) Other electronic equipment	Adjusts equipment for operation on desired frequency and ensures that frequency is within specified tolerance.
b. Using special purpose equipment to obtain data	Operate chronograph to compute muzzle velocities.
III. System Operation	
A. Target engagement	
1. Target acquisition	
a. Visually acquired	
(1) Detection, identification, discrimination	

TABLE 3-2
TASK STRUCTURE TAXONOMY

Part 2: Operation of Systems

Section A: Primary Functions (Vehicle operation, target engagement, and communication) (Continued)

CATEGORIES	EXAMPLES
(a) Visual detection, identification	Identifies enemy armor and other targets.
(b) Electronic discrimination	Applies knowledge of IR discrimination techniques to detect, acquire, and engage hostile targets.
(2) Ranging	
(a) Visual range estimation	Estimates ranges to targets.
(b) Using range finder	(Prepares rangefinder). Determines range to target.
b. Electronically acquired (e.g., by radar)	Detects, locates and reports target data by operating radar.
2. Operating Electronic Command Station	Operates the Target Area Display System and other fire control devices.
3. Firing on Target	
a. Loading	Loads and clears machine guns.

TABLE 3-2
TASK STRUCTURE TAXONOMY

Part 2: Operation of Systems

Section A: Primary Functions (Vehicle operation, target engagement, and communication) (Continued)

CATEGORIES	EXAMPLES
b. Aiming, firing weapons	
(1) Missiles	Fires missiles.
(2) Mortar	FIRES MORTAR. Sets/lays mortar for deflection and elevation. Maintains proper sight picture. Loads and fires mortar.
(3) Conventional rounds	
(a) Light infantry weapons	Fires individual and crew-served weapons in defense of position.
(b) Cannon, vehicle mounted weapons	Sets and lays for quadrant elevation.
c. Immediate action	Takes immediate action on misfire.
d. Requesting, adjusting fire support	Requests and adjusts indirect and aerial fire.
B. Communication Systems (electronic)	
1. Complete systems (transmit and receive)	
a. Common radio or wire communication	Uses radiotelephone procedures.

TABLE 3-2
TASK STRUCTURE TAXONOMY

Part 2: Operation of Systems

Section A: Primary Functions (Vehicle operation, target engagement, and communication) (Continued)

CATEGORIES	EXAMPLES
b. Specialized systems	
(1) Adjustments	
(a) Tuning and adjustment	Tunes, adjusts and aligns receiving and transmitting equipment for maximum performance.
(b) Antijamming	Recognizes and reports electronic countermeasures. Applies electronic counter-countermeasures.
(2) Using designated devices or procedures	
(a) Security measures	Coordinates utilization of cryptographic or other security measures.
(b) Devices	Operates patch and test facilities and interconnect facilities as directed.
(c) Procedures	Performs satellite systems handover and power balancing procedure as required.
(3) Circuit control	
(a) Adapting to malfunctions	Places spare equipment in operation during failure of on-line unit.

TABLE 3-2
TASK STRUCTURE TAXONOMY

Part 2: Operation of Systems

Section A: Primary Functions (Vehicle operation, target engagement, and communication) (Continued)

CATEGORIES	EXAMPLES
(b) Circuit utilization	Places additional authorized circuits in operation as required by traffic load.
(4) Administration	
(a) Coordination with other broadcasters	Coordinate with local using agencies, other military service, and commerical communicating organizations in matters related to circuit performance, capabilities and utilization.
(b) Tape storage	Stores, processes, updates, inventories, identifies and files magnetic tapes in the tape library.
c. Special jobs	
(1) GCA: Ground control of aircraft from radar	Provide radar approach control services....
(2) Civilian executive communication	MOSC 72H10: Operates communications equipment in support of the President, Vice President, their staffs, the Secret Service support elements of the Executive Branch of the Government.

TABLE 3-2
TASK STRUCTURE TAXONOMY

Part 2: Operation of Systems

Section A: Primary Functions (Vehicle operation, target engagement, and communication) (Continued)

CATEGORIES	EXAMPLES
2. EW/SIGINT Systems (receive only)	
a. Common EW tasks	
(1) Operating basic electronic equipment	Operates basic electronic equipment configurations comprised of radio receivers, special tyepwriters, teletype keyboard input devices.
(2) Electronic support measures (ESM)	Performs electronic support measures (ESM) for EW operations.
b. Message Analysis	
(1) Electronic analysis to locate, identify transmitters	Employs special identification techniques (SIT) including DF/AIT to recognize, identify and locate foreign radio transmitters.
(2) Content analysis	
(a) Collecting messages of potential value	Searches radio frequencies to collect and identify target communications.
(b) Translation	
language	Provides translation assistance to nonlanguage qualified analysts.
morse code	
(3) Conversion to ADP format	Reduces target communication data into automatic data processing (ADP) format.

TABLE 3-2
TASK STRUCTURE TAXONOMY

Part 2: Operation of Systems
Section B: Subordinate Functions

CATEGORIES	EXAMPLES
I. Power Generation	Starts and adjusts power units to assure delivery of power at prescribed readings.
II. Safety, First Aid, and Fire Prevention (in operating systems)	
III. Computer Operations (when not used with a combat system)	
A. Preparing equipment for operation	Prepares peripheral equipment such as mounting tapes on tape drives and loading cards on card reader/punch unit(s).
B. Operating machines	Operates tabulating equipment to prepare rosters and lists.
C. Functional analysis of wiring	Prepares wiring diagrams and wires control panels for the basic machine operations.
D. Administrative functions	
1. Scheduling	Performs functions of a scheduling clerk such as ensuring that run book/sheets are prepared, ...
2. Tape control	Performs duties of tape librarian such as logging of output tapes, pulling tapes for processing runs, ...
3. Input/Output function	Performs input/output functions such as decollating reports, booking or binding of reports.

TABLE 3-2
TASK STRUCTURE TAXONOMY

Part 3. Administration, Job Aids, and Constraints (for either operation or maintenance)

CATEGORIES	EXAMPLES
I. Administrative tasks	
A. Standard forms	Completes required operator forms and records. Prepares requests for turn-ins and repair parts.
B. Logs, records, files	Maintains station and equipment logs and records.
II. Understanding, following job guidance	
A. Using, printed job aids, such as TMS, FMS, schematics	Interprets use of military maps, communications charts and traffic diagrams and straight line power diagram.
	Reads and understands techincal manuals pertaining to repair of artillery.
B. Interpreting specialized codes or signals	Interprets information on grade stakes.
C. Applying theory	Applies electrical theory to series and parallel circuitry motors and generators.
III. Constraints	
A. Complying with regulations or SOP	Applies FAA and Army air traffic rules and regulations.
B. Safeguarding classified material	Safeguards classified material through proper use, distribution, storage and destruction.

TABLE 3-2
TASK STRUCTURE TAXONOMY

Part 4: Maintenance

CATEGORIES	EXAMPLES
I. General Description	
A. General operator maintenance (without mention of specific actions)	
B. Generic specification of equipment maintained (usually used in combination with some action from the other categories, e.g., "troubleshoots electronic equipment.")	
1. Electronic	
2. Electrical	
3. Electro-mechanical	
4. Mechanical	
5. Hydraulic	
6. Pneumatic	
7. Optical	
8. Infrared	
9. Digital control	
10. Heat transfer	
11. Training devices	
12. Microwave	
13. Radar	
14. Laser	
15. Other (list)	

TABLE 3-2
TASK STRUCTURE TAXONOMY

Part 4: Maintenance (Continued)

CATEGORIES	EXAMPLES
II. Maintenance Actions	
A. Preventive Maintenance	
1. Inspection	
a. Of general appearance	
(1) electrical	Visually inspects circuits for faulty insulation, poor electrical contacts, and broken or worn electrical components.
(2) other	Inspects major components of weapons for such defects as rust, scale, looseness of sights, and condition of barrel.
b. By moving parts manually	Operates assemblies manually to test functioning and ease of operation.
c. By observing in action	Observes action of main electrical, hydraulic, and mechanical components for evidence of abnormal operations.
2. Adjustment	Adjusts mechanical and optical components.
3. Servicing	Cleans, lubricates, paints and conditions.
4. Disassembly or reassembly	

TABLE 3-2
TASK STRUCTURE TAXONOMY

Part 4: Maintenance (Continued)

CATEGORIES	EXAMPLES
B. Testing and diagnostics	
1. Troubleshooting (isolation of fault to specific assembly or part)	Troubleshoots rotor system malfuntions.
2. Testing	
a. Initial and final checkout	Performs initial and final checkout and inspection of designated system items and their assemblies and subassemblies.
b. "Test Operates"	Test fires weapons.
c. Performing special test procedures	Performs gas pressure tests.
3. Precision measurement (of dimension)	Measures tolerances of parts with precision instruments and special tools.
C. Decisions	
1. Determination of level of repair (organizational, support)	Evaluates the condition of small arms and determines echelon of maintenance or repair required.
2. Determination of kind of repair	

TABLE 3-2
TASK STRUCTURE TAXONOMY

Part 4: Maintenance (Continued)

CATEGORIES	EXAMPLES
3. Disposition of unserviceable equipment	
D. Corrective actions	
1. Removal, replacement	
2. Calibration	Performs "C" level calibration and repair as authorized on designated test equipment.
3. Repair	
a. Overhauling	
b. Repairing electrical system	Rewires circuits.
c. Mechanical repair, fabrication	Performs repair operations by filing, boring, grinding, and drilling with hand and power tools.
4. Alignment (of systems with each other, and with geography)	Provides technical assistance in orientation, alignment, or synchronization of ICWAR, ICC, IPCP, BTE, and IFF.

TABLE 3-2
TASK STRUCTURE TAXONOMY

Part 4: Maintenance (Continued)

CATEGORIES	EXAMPLES
III. TOOLS AND METHODS USED ON JOB	
A. Using tools and test equipment	
1. Electronic, electrical	
2. Mechanical	Employs common and specialized mechanic's handtools.
3. Special shops	Operates Shops 2 and 3 in conjunction with other HAWK MOS personnel.
4. Maintenance of test equipment	
a. Operator maintenance	Uses and performs user maintenance on common and special tool and ground support equipment required for helicopter maintenance and ground handling.
b. Other	
B. Safety practices in maintenance, and related actions	Applies safety precautions when working around high voltages and performs emergency action in the event of injury.
C. Special operation, requirements	
1. Hoisting, rigging, hauling of heavy objects	Operates hoisting equipment to move and position heavy parts.
2. Climbing, or other unusual maneuvers	Climbs poles and operates pump equipment.

TABLE 3-3

SUPERVISORY FUNCTIONS IN MAINTENANCE

CATEGORIES	EXAMPLES
1. Direct contributions to unit maintenance	
A. Scheduling work	Coordinates, plans and schedules electrical work assignments.
B. Providing guidance in work	
1. Instruction, demonstration	
a. On-the-job training (OJT)	
(1) maintainers	Conducts on-the-job training.
(2) operators	Assists in training of operators in operator level maintenance.
b. Helping to solve difficult problems	Gives direction and instructions in resolving complex maintenance problems. Diagnoses causes of unusual malfunctions.
2. Monitoring	
a. Inspecting products of work	Inspects work or repair crews engaged in maintenance of artillery pieces.
	Certifies airworthiness of aircraft.
b. Checking work methods	Determine faulty work practices and demonstrates proper maintenance and troubleshooting techniques.

TABLE 3-3
SUPERVISORY FUNCTIONS IN MAINTENANCE (Continued)

CATEGORIES	EXAMPLES
II. Administration of unit maintenance	
A. Establishing, maintaining systems	
1. Programs (for effective work procedures)	Supervises the aircraft configuration control program and the spectrometric analysis program. Insure compliance in the test measuring/diagnostic equipment calibration and recertification interval schedules.
2. Files of publications and data	Maintains reference library of technical manuals and regulations.
3. Requisitioning and spare parts	Supervises the requisitioning and stockage of supplies and repair parts.
B. Planning and reporting	Estimates man-hours, parts and cost required in repair of crash damaged aircraft.
	Supervises the preparation of technical forms and reports.
C. Personnel functions	
1. Evaluation of personnel	Prepare evaluation reports of subordinate personnel.
2. Testing, and preparation for testing	Assists personnel in preparing for skill qualification tests.
3. Personnel actions	Recommends personnel for promotion, reduction and separation, disciplinary action and courts-martial.

TABLE 3-3

SUPERVISORY FUNCTIONS IN MAINTENANCE (Continued)

CATEGORIES	EXAMPLES
III. Personal leadership roles	
A. Special positions	Perform heavy lift helicopter crewchief duties.
B. Technical advisory service	Advises aircraft technical inspectors on maintenance practices, procedures, and techniques.
IV. Functions in other units	
A. Inspection	Inspects equipment of using units periodically, prepares inspection reports, and advises using units on operation and minor maintenance of equipment.
B. Mobile technical assistance	Provides technical assistance to supported units.

REFERENCES

Department of the Army, Enlisted Career Management Fields and Military Occupational Specialities, AR 611-201, September 1982.

Department of the Army, Qualitative and Quantitative Personnel Requirements Information (QQPRI), AR 71-2, July 1982.

Matlick, R.F., Berger, D.C., Knerr C.M., and Chiorini, J.C. Cost and training effectiveness analysis in the Army life cycle systems management model (Technical Report 503), U.S. Army Research Institute for the Behavioral and Social Sciences, September 1980.

Rhode, A.S., Skinner, B.B., Mullin, J.L., Friedman, F.L., and Franco, M.M. Manpower, personnel, and training requirements for materiel system acquisition (Research Product 80-27), U.S. Army Research Institute for the Behavioral and Social Sciences, October 1980.

DEVELOPMENT OF ALGORITHMS AND PROCEDURES TO TRANSLATE BEHAVIORAL REQUIREMENTS INTO MOS

The Military Occupational Specialty (MOS) Structure Taxonomy and Task Structure Taxonomy need procedures and guides for the Army users to apply them in determining MOS for developmental items. Application of the taxonomies varies with the data available at each phase of the Life Cycle System Management Model (LCSMM) and the MOS decision required. The logic and procedures for use of the taxonomies, described in Tasks 3 and 4 of the Statement of Work (SOW), therefore, take those factors into account.

Objectives

The objectives of Tasks 3 and 4 are to:

1. Develop an algorithm to translate the behavioral requirements (derived from Task Descriptive Data (TDD) using the taxonomy developed in Task 2) into MOS and other relationships

2. Define the translation process

3. Specify parameters and relationships resulting from implementation of the algorithm

4. Identify and define the elements of the algorithm to distinguish output quality and quantity throughout the phases of the LCSMM

5. Provide detailed procedures for using the behavioral requirements, algorithm, and taxonomy

6. Indicate use of these procedures to provide a smooth transition from TDD to behavioral requirements and then to MOS and other relationships

7. Tailor the procedures, where appropriate, to accept various levels of data specificity based upon location in the LCSMM

The algorithms for MOS determination using the taxonomies and progress to date on the procedures are presented in this section.

PROCEDURE FOR DETERMINING MOS AND GENERATING TASK LISTS

The process of determining MOS and related matters is outlined in Table 4-1 which lists the determinations made, the part of the taxonomy that is used, the required input information, the agency that makes the determination and the document for which the determination is required (usually QQPRI). Table 4-2 specifies when the various Qualitative and Quantitative Personnel Requirements Information (QQPRI) must be submitted, and the level of data specificity involved in each submission.

Table 4-1 shows that the MOS Structure Taxonomy must be applied first to determine a Tentative MOS (TMOS), or to ascertain that no current MOS is suitable for the new equipment. Then the user applies the Task Structure Taxonomy to analyze the kind of action performed with the equipment. This two-step process corresponds with current use of AR 611-201, Enlisted Career Management Fields and Military Occupational Specialties.

IDENTIFYING MOS FOR DIRECT OPERATORS AND MAINTAINERS

Constraints for LSAR

The MOS Structure Taxonomy is first applied early in the conceptual phase to determine constraints on contractors as to the maintenance MOS they can assume in design of the new system. This constraint prevents design of systems that only exceptionally capable people can maintain. Engineering design data subsequently confirm or disprove the TMOS as the logical choice. The method used in determining these MOS is the same as for QQPRI, described below.

Table 4-1
INPUT/OUTPUT FUNCTIONS OF TAXONOMIC SYSTEM

Output (Determination)	Taxonomic Instrument	Input Required	Document	Agency*
Tentative MOS (TMOS) of System Maintainers	MOS Structure Taxonomy (MST), Part 1	System type	LSAR Constraint	Materiel Developer
TMOS of direct operators, maintainers	MST, Part 1	System type	QQPRI, req. 5 (MOS list)	Materiel Developer/ New equipment training analyst (NETA)
MOS of support personnel	MST, Parts 1&2	System type BOIPFD	QQPRI, req. 5 (MOS list)	Materiel Developer NETA
Exceptions to task list	Task Structure Taxonomy (TST)	TMOS, task list	QQPRI, req. 6 (task list)	Materiel Developer NETA
			NET	
Task list	TST	New MOS, performance requirements	QQPRI, req. 6 (task list)	Materiel Developer NETA
			NET	

* LSAR constraint occurs in the Conceptual Phase. QQPRI submissions are detailed in Table 4-2, and QQPRI requirements 1-7 are described in Figure 3-1

Table 4-2
QQPRI SUBMISSION REQUIREMENTS

	TQQPRI	FQQPRI
Submission Deadline*	9 months before DCP II (end of Phase II)	21 months before DCP III or 33 months before EAD
Data Specificity:		
input	intermediate functions	detailed performance functions
output	task categories, incomplete lists	complete task lists, or exceptions

* Submission deadlines are specified in AR 71-2, 15 June 1982, pp. 3-1 and 3-2.

Identifying MOS for QQPRI

QQPRI, submitted at various phases in the LCSMM, require a list of MOS to operate, maintain, and support the system. Increasingly precise reporting is required during Phase II (a tentative version, TQQPRI) and during Phase III (a final version, FQQPRI). If maintenance MOS were determined as constraints in LSAR, then they need to be confirmed, and other MOS determined.

The first step is to determine, if possible, a TMOS for each direct operator and maintainer position in the new system. This step applies the MOS Structure Taxonomy (Part 1 of Table 3-1), which includes all such MOS in the Army, except for Reserve Forces MOS, which are listed in Part 3 of Table 3-1. An algorithm for this determination is presented in Figure 4-1.

The range of possible MOS is narrowed by finding a category that corresponds to the kind of new equipment and the functions for its operation. The category includes all MOS, both operator and maintainer, for one kind of system, except when they are not associated with a common set of equipment items; then they are in adjacent categories.

Categories 1 through 7 contain primary military systems, including aviation, weapon systems, combat vehicles, electronic sensors and communication systems. Categories 8 through 11 contain support systems, including engineering equipment and transportation systems. First the user chooses between these two major sections because they contain different sets of MOS even when the MOS titles and job skills appear similar. The support systems involve no system-specific MOS, except for certain computer repairers (MOS 34E and 34K). Next, within the primary military systems, the categories are divided according to whether or not there are any system-specific MOS. The first two branches (on the first page of Figure 4-1) contain

Figure 4-1
Algorithms for Determining Tentative MOS (TMOS)

Required input:

1. System type
2. One position, direct operators or maintainers
3. Classification of position functions as
   a. operator
   b. organizational maintenance
   c. support maintenance
4. General information about duties involved (e.g., maintenance concept)

Does system relate to primary military functions? (Aviation, communication, weapon systems, combat vehicles, electronic sensors) — no → 1

yes ↓

Is system function in a category where all MOS are generic? (1.1 Aviation, 1.2.3 Arty Cannon, 1.5.2 AD Radar, 1.6 Electronic sensors, 1.7 Communication) — yes → 2

no ↓

3

Figure 4-1 (Continued)

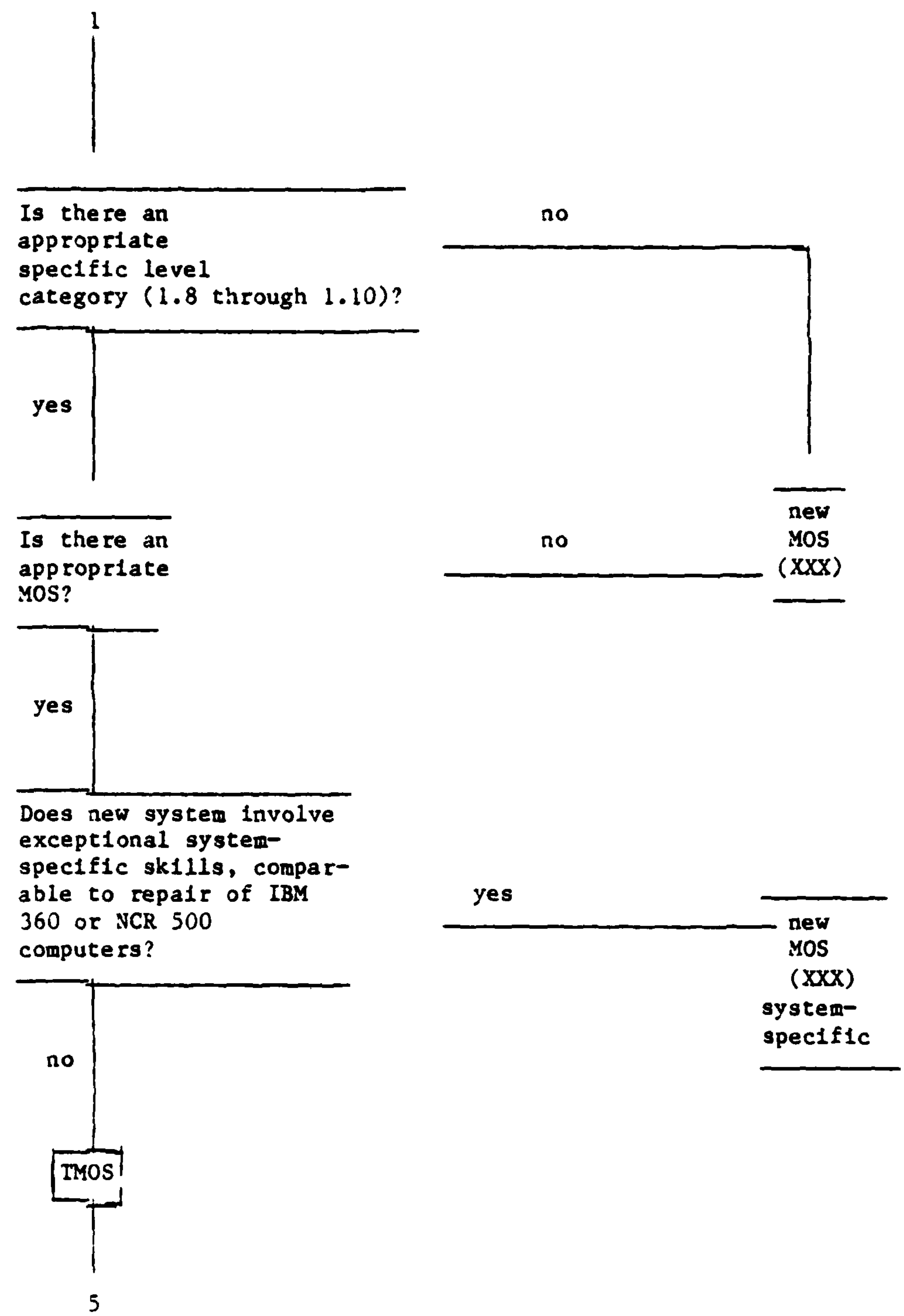


Figure 4-1 (Continued)

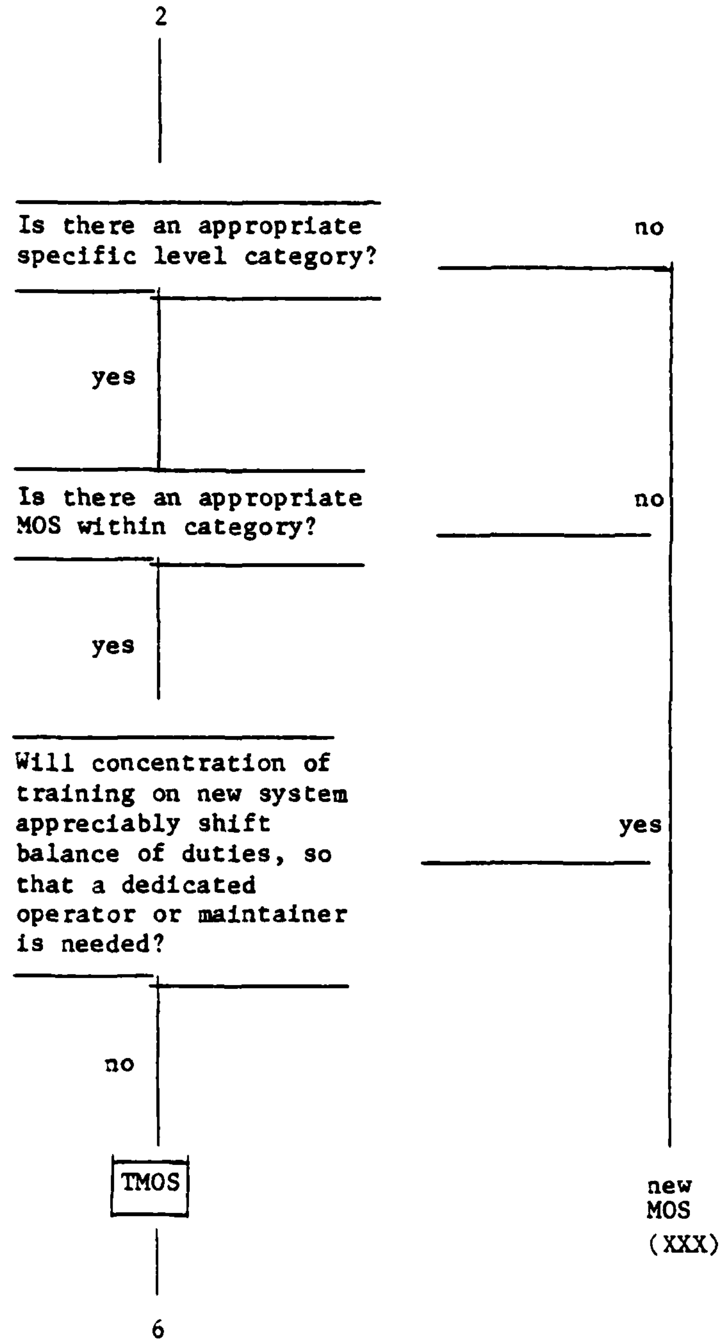


Figure 4-1 (Continued)

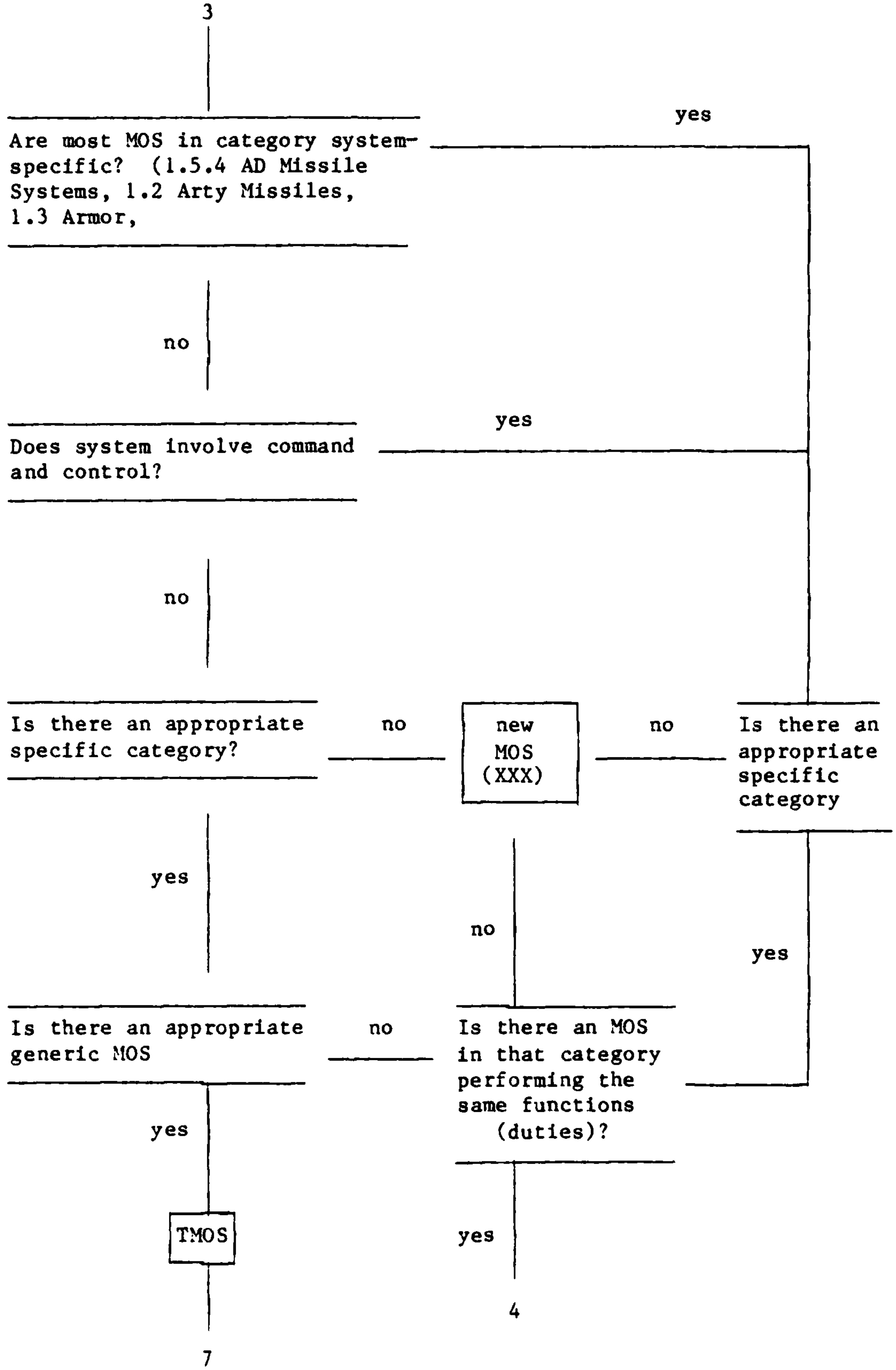
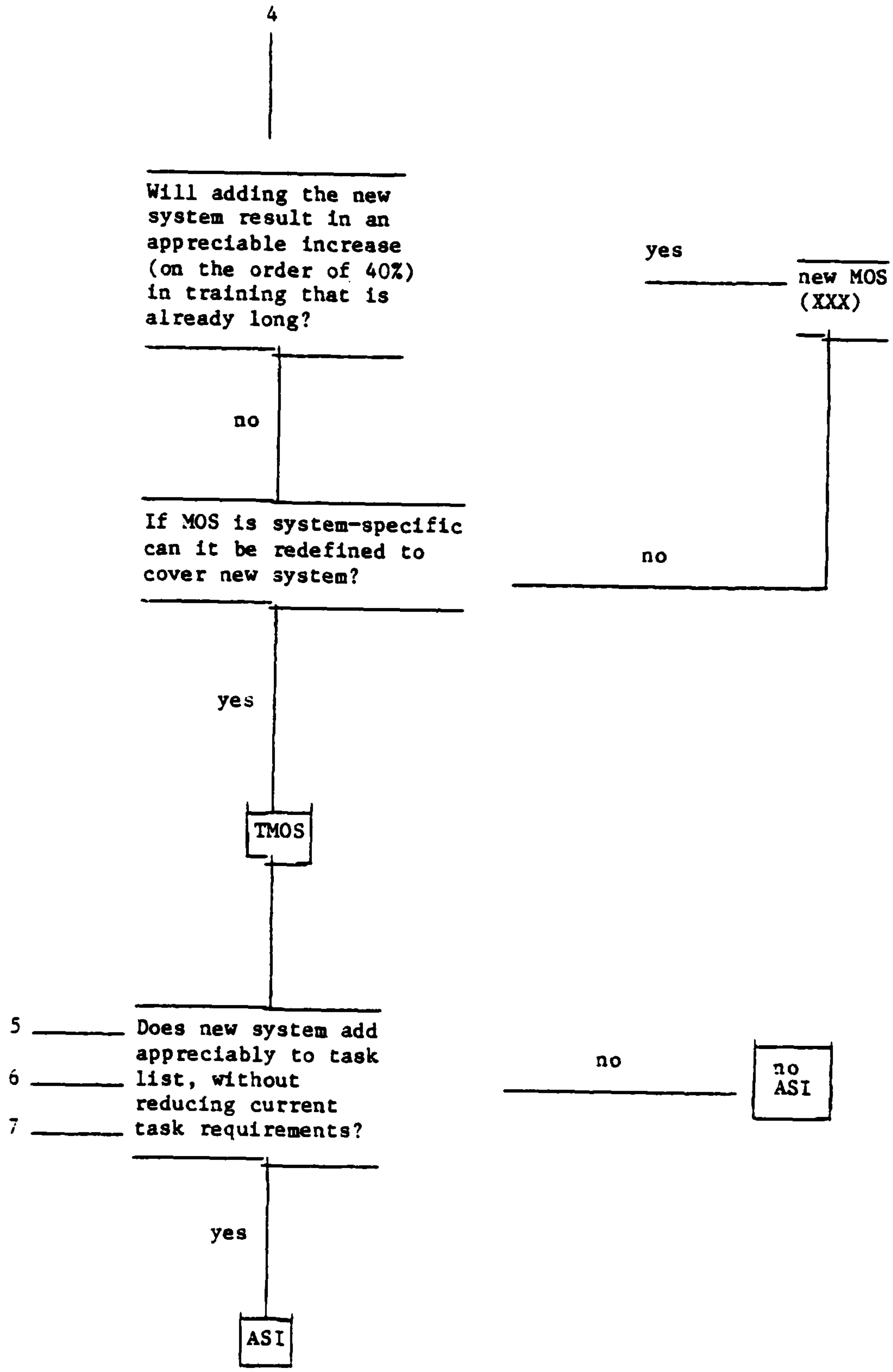


Figure 4-1 (Continued)



contain those instances where generic MOS for new equipment are probable. Similar considerations apply in subsequent determinations. No match for the functions required for the new system may be found, of course, and the corresponding branches are shown along the right margin of the second and third pages of the flow chart.

The remaining branch (which is continued on the fourth and fifth pages) covers the more complex cases where many MOS are system-specific, and have long training. In these categories a new MOS is likely.

The most appropriate MOS is selected after narrowing the field of consideration to one category at the most specific level. First the MOS for the appropriate level of maintenance or operation is indicated in columns of X's. The user reduces the number of MOS under consideration by eliminating those that, from their titles, are clearly inappropriate.

Next, the user considers whether the remaining MOS are generically defined, or defined in terms of a specific system. Generic MOS are checked by consulting the MOS specifications in AR 611-201, especially the general descriptions of the MOS, which refer to major subsystems and differentiate the duties from other MOS. A single MOS is usually a clear candidate, but if more than one is reasonable, relative merit should be indicated in writing in the QQPRI. A single MOS choice is needed during development, but it may be changed as better information becomes available. It may also be changed because of gradual accretion of equipment items and total training time.

No current MOS will be appropriate in perhaps 10 percent of the new systems. When the new system departs sharply from its predecessors, a very different kind of training is required. Two examples are TOW and PATRIOT, which were discussed in the previous chapter. With the TOW system, the logical choice would have been 11B (Infantryman), but the TOW system was considered so important that a new MOS, 11H (Heavy Anti-Armor Weapons Infantryman) was created to accommodate this kind of weapon. In the case of PATRIOT (an AD missile system) all other systems of this kind have system-specific MOS, so it seemed likely that PATRIOT would follow the same pattern, providing the same kinds of considerations were involved. Choice of a system-specific MOS lowers the probability of another system being added to its responsibility. Adding the new system would require changing the name and definition of the MOS and increasing the length of training to an unacceptable level.

The user should consider whether the other MOS in the category are defined in system-specific terms; since system-specific MOS are concentrated in certain categories, it seems likely that new systems in those categories will also receive new, specific MOS. Conversely, those categories that contain no system-specific MOS seem unlikely to get any for future systems. These factors are reflected in Figure 4-1.

If there is a system-specific MOS that seems appropriate for a new system, the user should consult the general description of duties for the MOS in AR 611-201. This description may reveal differences in kinds of components (e.g., a shift to built-in test equipment), in methods of operation, or a shift in responsibilities at each duty position.

GENERATING TASK LISTS AND CONFIRMING MOS

The procedure for generating task lists begins with noting which task categories in the Task Structure Taxonomy are used in each position with the new equipment. This procedure is summarized in Table 4-3.

Table 4-3
Procedure for Using Task Structure Taxonomy

Purpose: To generate task lists (or exceptions) for operator or maintainer position on new equipment, and to confirm TMOS (identified with MOS Structure Taxonomy) when there is one.

Necessary Input: Familiarity with duties and tasks required for new system. TMOS if there is one, and task lists if available.

Procedure:

1. Circle numbers or letters of categories in Table 3-2 where duties or tasks are required of person on new system. Circle specific categories when possible, but circle more general categories as applicable when more specific categories cannot be determined. Circle categories as appropriate in each of the following Parts or Sections of Table 3-2:

   a. Common Soldier Tasks in Part 1.

   b. Primary functions for operator in Part 2, Section A (vehicle operation, target engagement, and communication).

   c. Secondary functions in Part 2, Section B. (Power generation, safety, computer operations).

   d. Administration, job guidance and constraints in Part 3.

   e. Maintenance functions in Part 4.

2. If there is no TMOS, generate list of tasks under each category circled. Use task lists from any similar MOS to suggest ones that should be listed for new system. Enter task lists in QQPRI in accordance with Sixth Requirement.

3. If there is a TMOS, obtain task lists and categorize each task using the Task Structure Taxonomy (Table 3-2).

   a. Put a minus sign (-) beside those tasks that will not be required with new equipment.

   b. Add any new tasks required by the new equipment, and designate these with a plus (+).

   c. Of the remaining tasks (no + or -) check (✓) those that are changed appreciably. Briefly explain in writing the nature of each change.

   d. Enter lists of exceptions (task designated +, -, or ✓) in QQPRI in accordance with the Sixth Requirement.

Table 4-3
Procedure for Using Task Structure Taxonomy (Continued)

4. To verify or disprove TMOS (if there was one) review task list, paying special attention to changes (tasks designated +, -, or ✓). Put a check by any category where the task requirements for the groups as a whole have changed appreciably. Then decide whether the magnitude of change over all categories warrants changing MOS, or adding a skill designator (ASI). An ASI is indicated when there are many added (+) tasks, but few deleted (-) tasks, and when changed (✓) tasks do not require contradictory techniques.

After applying the MOS Structure Taxonomy to determine TMOS for each position in the new system, either a current TMOS is identified or it is not; these cases are discussed separately below. In either case, the Task Structure Taxonomy is used to generate current task lists which are subsequently used in design of training. When the new system is so different that there is no current matching TMOS, then there will be no available task list, and a framework is especially important for generating one. When there is a TMOS, the Task Structure Taxonomy is used to update the task list associated with MOS and to confirm that selection.

Generating a task list

The QQPRI requires the MOS recommendation to be accompanied by a list of system-unique tasks. This requires obtaining a task list for the old MOS, which may be used to identify the unique tasks. For each category where the new system differs significantly from the TMOS, tasks are added, deleted, or modified. The Task Structure Taxonomy provides a structured method for identifying differences.

Confirmation of TMOS

The last step in the procedure assesses the appropriateness of an MOS. The Task Structure Taxonomy is used to examine similarities and differences, without requiring detailed facts and task lists which are generally unavailable in early development. The taxonomy also provides a systematic means of limiting consideration of well known, and therefore trivial areas (e.g., common soldier tasks), thus focusing attention on the more significant areas.

When a great number of discrepancies or significant differences in task categories are found, the TMOS may be rejected and another one considered. Where only moderate differences are found, the TMOS may be retained as a working assumption, but the differences should be noted by task category in the QQPRI, in qualifying the answer to the sixth requirement (task lists or exceptions).

IDENTIFYING MOS OF SUPPORT PERSONNEL

Requirement 5 of QQPRI requires identification of MOS for support personnel, in addition to MOS for direct operators and maintainers (Figure 3-1). The support personnel MOS are identified on the basis of type of equipment using Table 3-1. Some of these MOS may also be identified on the basis of support equipment identified in Basis of Issue Plan Feeder Data (BOIPFD), and listed in the QQPRI in fulfilling Requirement 2. Supervisory and related MOS in the units using the equipment are identified using Part 2 of the MOS Structure Taxonomy.

Procedure

The first step is to identify support equipment in the current inventory that is required by the new system (e.g., generators, test stations, and trucks). Some of these MOS may be identified on the basis of associated equipment and component equipment from BOIPFD: identifying these support items is also required as an entry in QQPRI (Requirement 2). The necessary data input are provided in BOIPFD. MOS associated with these items are identified in the MOS Structure Taxonomy (Table 3-1, Parts 1 and 2) by the job duties.

Additional MOS are needed for support that are not identified with support equipment; for instance, a Ma 'iinist (44E) may be needed who is not directly associated with support equipment but who provides a service. Each kind of service requires a support chain of MOS; for example, providing fuel requires fuel specialists to manage distribution, truck drivers to transport the fuel, and mechanics to maintain the trucks that transport the fuel. Identifying the support chains assists in generating a long and exhaustive list of MOS, as indicated by the sample on pp. B-3 and B-4 of AR 71-2.

Prominent support chains are listed in Table 4-4. The user identifies each required support chain then finds the corresponding MOS in the MOS Structure Taxonomy (Parts 1 and 2 of Table 3-1). The support chain MOS are combined with those for support equipment, described above. Additional support chains may be identified for new systems. One likely source is Engineering (MOS Structure Taxonomy categories 1.8 and 2.8), especially that involved in construction.

MOS for supervisory and other personnel who are associated with direct operators and maintainers in their units must also be identified, although this is done as part of the Basis of Issue Plan (BOIP), rather than in the QQPRI. These associated MOS are identified by noting .ll categories for direct operators and maintainers in Part 1 of the MOS Structure Taxonomy, and then locating the corresponding categories in Part 2. The supervisory functions are checked in Table 3-3 to identify required supervisory personnel.

TABLE 4-4
COMMON SUPPORT CHAINS OF MOS

Prominent support chains are identified in the following list, which is to be used in conjunction with Table 3-1 (MOS Structure Taxonomy) to determine the MOS involved:

1. Fuel. Fuel specialist MOS are listed in Section 2.10.5 of Part 2 of Table 3-1. This chain would also involve transportation for the fuel (Section 1.9), including truck drivers, maintainers, and related personnel.

2. Transportation (Section 1.9). Heavy combat equipment, including vehicles, generally must be driven to the battle zone. A somewhat different transportation factor is involved with systems that are regularly mounted on a standard truck, because this requires a dedicated vehicle.

3. Ammunition (Section 2.10.4). This section lists several MOS, which are peculiar to certain kinds of systems. This chain would also involve transportation, as did fuel.

4. Power generation (Section 1.9.1). Personnel for operating generators come from particular systems using power, but maintenance is combined with vehicle maintenance.

5. Utilities (Section 1.10.1). Certain systems require air conditioning or special heating.

6. Instrument maintenance (Section 1.10.3). Some kinds of systems are particularly dependent on this kind of maintenance specialist.

7. Miscellaneous maintenance (Section 1.10.8). Certain kinds of systems are dependent upon Machinists (44E) and Metal Workers (44B).

Application of Support chains

Support chains of MOS are used to generate lists needed for QQPRI to determine the organizational impact of the new system. Support chains have potential application in the current BOIP process and in AUTOMANPERS. The rational structure associated with support chains of MOS is particularly important for a Computer Interactive System for Determination of Manpower and Personnel Requirements (AUTOMANPERS) model, where each chain would correspond with a subroutine in the model. With fuel, for instance, the total personnel resources devoted to fuel transport, storage, and accounting would be allocated among systems that use fuel, probably on the basis of mileage and utilization. The parameters would be adjusted when fuel consumption estimates are updated, without having to adjust other aspects of the model. Thus one could project personnel requirements while making on-line adjustments.

SUMMARY

A taxonomic method is presented for determining MOS for direct operators and maintainers of new systems, and for generating tasks lists for each MOS. The method also generates lists of MOS for support personnel.

Tentative MOS of direct operators or maintainers are determined by application of the MOS Structure Taxonomy, which reflects relations among MOS as specified in AR 611-201. A flow chart is provided to aid in these selections. The tentative MOS are confirmed, and task lists are generated by application of the Task Structure Taxonomy, which classifies tasks and duties within MOS. MOS of support personnel are identified by application of the MOS Structure Taxonomy, to provide input to the BOIP and to a

MANPERS model. These support MOS are linked together in rational chains which provide particular kinds of service (e.g., fuel). In an AUTOMANPERS system, each chain would have a corresponding subroutine.

The above determinations are required for QQPRI, which must be submitted in tentative form (TQQPRI) during Phase II of LCSMM, and in a final form (FQQPRI) during Phase III. Task 1 findings indicate that these submission dates are too late for many purposes, and that a much earlier submission, a conceptual QQPRI, would be desirable. The taxonomic method presented here is an aid in making many of the determinations on the basis of data available in the conceptual phase.

The task lists developed for QQPRI are the basis for estimating impact on training, and for developing training. Task and Skill Analysis (TASA) and Instructional System Development (ISD), for instance, require as a first step the generation of task lists. The categories of the Task Structure Taxonomy are associated with training strategies that have been evaluated with many Army systems; thus, the structured tasks lists also suggest training methods. For example, using electronic test instruments is commonly taught in a special lab, where the novice can concentrate on the basic operations until these are mastered. Training strategies are associated with the terms used in the taxonomy (e.g., in the ISD model). A Taxonomy provides a tool for analyzing tasks in groups, rather than one at a time, in isolation.

REFERENCES

Department of the Army, Enlisted Career Management Fields and Military Occupational Specialties, AR 611-201, September 1982.

Department of the Army, Qualitative and Quantitative Personnel Requirements Information (QQPRI), AR 71-2, July 1982.

CONCLUSIONS

The following conclusions are subject to revision based upon additional information obtained during the continuation of Phase I research.

It is concluded that the overall Army manpower and personnel requirements determination process within the context of Army Programs for Force Modernization is started too late in the system development cycle and is complex, confusing, not well understood and, in instances, not well coordinated.

It is concluded further that:

1. The manpower and personnel requirements information available early in the processes, prior to LCSMM milestone 0, is lost because of the absence of a formalized recording capability.

2. The procedures articulated in AR 71-2 relative to preparing QQPRI cover HQDA policy, primary responsibilities, and overall QQPRI flow and do not include "how-to" procedures applicable to internal major command information developmental procedures.

3. During the QQPRI flow between the materiel developer, combat developer, and trainer, the question of whether or not a new or revised MOS or ASI is required must currently be resolved without adequate ground rules for what constitutes a basis for departing from the Career Management Fields (CMF) and associated MOS and ASI published in the AR 611-series regulations.

4. The LCSMM point where FQQPRI must be submitted to TRADOC is frequently too late in the development cycle to provide adequate lead time for personnel acquisition, training, and deployment. Response time

provided the personnel cummunity is frequently inadequate and, as a result, extraordinary measures are required or deployment schedules are slipped.

5. The fact that QQPRI content and purpose are to provide data pertaining to only one set or piece of developmental equipment is generally not understood. For example, the OQPRI for the Abrahms Tank would be prepared for a quantity of one. The BOIPFD and QQPRI are incomplete without organizational and operational, and maintenance conceptual information; therefore, this information must be available to formulate the BOIP. The BOIP includes personnel change information from the QOPRI and BOIPFD applied at the TOE, TDA, MOS, grade, and quantity level of detail. Therefore, this information can be completely different from the QQPRI information originally prepared by the NET Analyst because it has become an <u>organizational</u> OQPRI when reflected in the BOIP.

6. MACRIT data are difficult to use and frequently incorrectly used.

7. The idealized baseline for estimating manpower and personnel requirements is achievable within state-of-the-art procedures.

8. In selecting appropriate MOS for direct operators or maintainers of new equipment, the dominant consideration is how that equipment relates to the functional structure among MOS in the Army. This MOS structure reflects organization of Army units and kinds of equipment. It also involves classification of duty positions in operations, organizational maintenance, or support maintenance. This selection process is not completely clear because of the absence of specific rules or criteria to support the MOS decision process that relates degree of job content change to a need for a revised or new MOS or even a new ASI.

9. A secondary consideration in determining MOS is the kinds of behavior required (e.g., troubleshooting, driving, or engaging targets).

10. An objective method of determining MOS was devised, applying an MOS Structure Taxonomy for a tentative determination, which is confirmed by application of a Task Structure Taxonomy that classifies duties and tasks as an aid in determining an Army MOS.

11. The Task Structure Taxonomy may also be used to generate organized task lists which are necessary for development of training.

12. Selected additional research is still required and ongoing concerning QQPRI preparation, MOS decision processes, and usable job aids and procedures that will improve the overall QQPRI and BOIP development process.

RECOMMENDATIONS

The following recommendations are subject to revision based upon additional information obtained during the Phase I research.

It is recommended that specific procedures and job aids be developed to support implementation of the systems and procedures aspects of the "ideal baseline" concept addressed in the discussion of Task 1. This would involve definition of data bases, data and document flows, timing considerations, distributed processing requirements, and interfaces with existing and developing automated systems. It would also encompass proposed revision to and expansion of existing guidance relating to new system manpower and personnel requirements definition and the QQPRI and BOIP process and lead logically to TOTAL MANPERS, MARMIS, and AUTOMANPERS research and development activities during Phases II and III. Substantive changes to be considered in the development of procedures would include:

- Provision for tracking of manpower estimates and trade-off resources commencing with the concept formulation prior to milestone I and continuing until the project is either discontinued or successfully completed.
- Preparation of a conceptual BOIP early in the development process (in addition to tentative and final BOIP).
- Supporting systems capabilities to record data, track progress, and facilitate interface to the "official" Army force structure systems.

This work would complement and be fully integrated with the continuing development of MOS definition procedures and tools addressed in the next paragraph.

It is also recommended that development and evaluation of the algorithms and procedures for application of the MOS Structure Taxonomy and the Task Structure Taxonomy be continued. Evaluations to date have been performed by personnel most directly involved within the project team; the next evaluations need to be made or performed by personnel who have not been directly involved with the taxonomic development (other people in HumRRO, GRC, or ARI). The algorithms for applying the taxonomies should be refined and the procedures clarified and expanded. Preparation for evaluation outside the ARMPREP team can be conducted concurrently with the revisions of the products and the execution of subsequent Phase I tasks. These algorithms should be incorporated into their appropriate position in procedures and job aids for BOIPFD, QQPRI, and BOIP preparation.

Implementation of these research recommendations will require additional interviews and analysis of the QQPRI process. The current analysis, presented in this report, is thorough at the level of document flow but requires some additional detail at the level of data within the documents. This continued analysis should involve review of the data flow, interview with additional cognizant Army personnel, and complete documentation of behavioral details. Some of the interviews may be with the same personnel or agencies contacted earlier but will be at a more detailed level.

In summary, the remaining Phase I tasks, involving the demonstration and evaluation of methods and procedures currently being developed, and preparation of a MANPERS manual, should continue. The principal continuing effort should be toward the development of procedures and tools to aid in MOS selection and the definition of specific procedures, flows, and job aids required to implement other systems and procedural improvements incorporated because of the "ideal baseline." The specific procedures, flows, and job aids are:

- MOS Selection and Decision Process
- Manpower Authorization Criteria (MACRIT) Use
- Basis of Issue Plan Feeder Document Preparation

- Quantitative and Qualitative Requirements Information (QQPRI) Preparation
- Basis of Issue Plan Preparation

REFERENCES

1. AFHRL, Expert Estimate Method of Generating Maintenance and Manpower Data for Proposed Air Force Systems: Users Guide, Evaluation, Report AFHRL-7R-79-79, Mar. 1980.

2. Charest, Geoffrey B., "A Young Turks View of Improving Army Acquisition of Nonmajor Programs," Army R, D & A Magazine, Mar.-Apr. 1982, p.6.

3. Department of the Army, Concept Paper, Prospects for Shortening Army Weapons Acquisition Intervals, (author unknown), Undated.

4. Department of the Army, Army Materiel Acquisition, AR 70-1 (with change 1), 1 May 1975.

5. Department of the Army, Product Improvement of Materiel, AR 70-15 (with change 1), 15 Jun. 1980.

6. Department of the Army, Outline Development Plan/Development Plan/Army Program Memorandum/Defense Program Memorandum/Decision Coordinating Paper, AR 70-27, 17 Mar. 1975.

7. Department of the Army, Type Classification of Army Materiel, AR 70-61, 1 Aug. 1978.

8. Department of the Army, Force Development, Basis of Issue Plans (BOIP), Quantitative and Qualitative Personnel Requirements Information (QQPRI), AR 71-2, Jun. 1982.

9. Department of the Army, Materiel Objectives and Requirements, AR 71-9, 7 Feb. 1975.

10. Department of the Army, Management System for Tables of Organization and Equipment (The TOE System) (with change 1), AR 310-31, 2 Sep. 1974.

11. Department of the Army, Equipment Authorization and Utilization Policies and Criteria and Common Tables of Allowances, AR 310-34 (with changes thru 5), 24 Feb. 1975.

12. Department of the Army, The Army Authorization Documents System (TAADS), AR 310-49, 15 Dec. 1980.

13. Department of the Army, New Equipment Training, AR 350-35, 15 Dec. 1970.

14. Department of the Army, Logistic Policies and Procedures (U), AR 381-143, 25 Mar. 1977.

15. Department of the Army, Military Occupational Classification Structure Development and Implementation, AR 611-1, 27 Apr. 1976.

16. Department of the Army, Commissioned Officer Specialty Classification System (with changes thru 10), AR 611-101, 15 Nov. 1975.

17. Department of the Army, Manual of Warrant Officer Military Occupational Specialties, (with changes thru 4), AR 611-112, 15 Nov. 1977.

18. Department of the Army, Enlisted Career Management Fields and Military Occupational Specialties, AR 611-201 (with changes thru 19), AR 611-201, 1 Oct. 1973.

19. Department of the Army, Cataloging and Supply Management Data, AR 708-1, 1 Apr. 1981.

20. Department of the Army, Standard Study Number System and Replacement Factors, AR 710-60, 9 Jan. 1979.

21. Department of the Army, Test, Measurement, and Diagnostic Equipment (with change 1), AR 750-43, 24 Jul. 1975.

22. Department of the Army, Integrated Logistic Support Management Model (ILSMM) and Glossary, DA Pam 700-127, 15 Apr. 1975.

23. Department of the Army, Army Adapted/Other Items Selected for Authorization/List of Reportable Items, SB 700-20, 1 Mar. 1982.

24. Department of the Army, Standard Study Number System and Replacement Factors, SB 710-1-1, 1 Apr. 1982.

25. Department of the Army, Management Plan for the Implementation of Actions Developed by Integrated Review of Problems Associated with the Fielding of Modernization Systems/Major Items of Equipment, Letter 5-80-5, 29 Sept. 1980.

26. Department of the Army, Integrated Logistic Support, AR 700-127, Apr. 1975.

27. Department of the Army, Integrated Personnel Support (IPS), TRADOC REG 600-4, June 1978.

28. Department of the Army, Life Cycle System Management Model for Army Systems, DA PAM 11-25, May 1975.

29. Department of the Army, Test and Evaluation During Development and Acquisition of Materiel, AR 70-10, Aug. 1975.

30. Department of the Army, Basic Policies for Systems Acquisition, AR 1000-1, May 1981.

31. Department of Defense (DOD), "Improving the Acquisition Process," Memorandum, 30 Apr. 1981.

32. DOD, Major System Acquisition, Directive No. 5000.1, Mar. 1980.

33. DOD, Major System Acquisition Procedures, Directive No. 5000.2, Mar. 1980.

34. DOD, Test and Evaluation, Directive No. 5000.3, Dec. 1979.

35. DOD, Specification Practices, MIL-STD-490, Oct. 1968.

36. DOD, Manpower Requirements Report for Fiscal Year 1980, Feb. 1979.

37. Deppner, Francis O., et al., Report of Input Data Quality, Identification of Manpower Requirements for New Weapon Systems and Incorporation of the Requirements into the Personnel Structure and Composition System (PERSACS), General Research Corporation, 1161-02-80-CR, McLean, VA, July 1980.

38. Deppner, Francis O., et al., Report of Task B, System and Procedures Documentation, Analysis to Determine Functional and Systems Requirements for an On-Line Structure and Composition System (SACS), General Research Corporation, 1070-01-79-CR, McLean, VA, Jan. 1979.

39. Office of Management and Budget, Major Systems Acquisitions Application of OMB Circular #A-109, OFPP Pamphlet #1, Aug. 1976.

40. Office of Management and Budget, Major System Acquisitions, Circular #A-109, 5 Apr. 1976.

41. SECNAV, System Acquisition in the Department of the Navy, Instruction 5000.1A, 17 Nov. 1978.

42. U.S. Government Accounting Office (GAO) Study, Guidelines for Assessing Whether Human Factors Were Considered in the Weapon Systems Acquisition Process, FPCD-82-5, 8 Dec. 1981.

43. U.S. GAO, "Major System Acquisition Management in the Department of the Treasury" (GGD-82-16), Letter, 29 Jan. 1982.

44. U.S. GAO, The Army Continues to Have Serious Problems Identifying Its Resource Requirements, GAO LCD-80-67, 30 Jun. 1980.

45. U.S. GAO, Effectiveness of U.S. Forces Can Be Increased Through Improved Weapon System Design, GAO PSAD-81-17, 19 Jan. 1981.

APPENDIX A*

Review of the Navy's HARDMAN Methodology

Contents

* We are grateful to Mr. Michael J. Hillelsohn for conducting the HARDMAN interviews and preparing initial drafts of this Appendix.

REVIEW OF THE NAVY'S HARDMAN METHODOLOGY

INTRODUCTION

The high cost of human resources has led the military services to adopt models for estimating them during the development and acquisition of new developmental items. The Navy's methodology for estimating manpower, personnel, and training requirements is HARDMAN (Military Manpower and Hardware Procurement). The goal of HARDMAN is "to facilitate the determination of manpower, personnel and training requirements during the early phases of the weapon system acquisition process" (Dynamics Research Corporation (DRC), 1980d, p.1). HARDMAN has four main objectives, as follows:

1. Institute procedures to address manpower, personnel and training requirements consistent with Navy and Department of Defense directives.

2. Provide the means for compliance with policy and acquisition procedures.

3. Develop tools and methods to assist program managers in considering the impact of system design on manpower, personnel and training.

4. Provide the Chief of Naval Operations with an assessment of manpower, personnel and training supportability before design decisions and resources allocations are made.

HARDMAN is reviewed to identify portions that can be used or adapted for ARMPREP.

ROLE IN THE ACQUISITION PROCESS

HARDMAN is applied while the system is in a design phase and continues throughout the weapon system acquisition process (WSAP) to evaluate man-machine trade-offs, maintenance concepts and training. HARDMAN determines human resources requirements; identifies high resource drivers, operational and support concepts, and policies that generate human resource demands; and provides the information for determining human resource/ equipment design trade-offs during the early phases of the WSAP.

Figure 1 shows the relation of HARDMAN to DSARC milestones. The first goal is front-end analysis, defined as the evaluation of requirements for manpower, personnel and training (MPT) during the early stages of the military system acquistion cycle.

Examples of HARDMAN contributions to DSARC/NSARC reports are:

Report	Contribution
Mission Element Needs Statement (MENS)	Determine logistics constraints and resource estimates to satisfy the MENS
Decision Coordinating Paper (DCP)	Summarize system and program alternatives and state reasons for selection of preferred alternatives
Integrated Program Summary (IPS)	Satisfy data/information required
Logistics Support Analysis (LSA)	Contribute to detailed LSA/LSAR during full-scale development phase
Navy Training Plan (NTP)	Contribute to the NTP during full-scale development
Preliminary Ship/Squadron/ Shore Manpower Document (SMD/SQMD)	Contribute to the SMD/SQMD during full-scale development

Initial HARDMAN analyses, at Milestone 0, emphasize large components of the system and are based on large distinctions between existing and proposed systems. Finer distinctions can be made at Milestone I, when

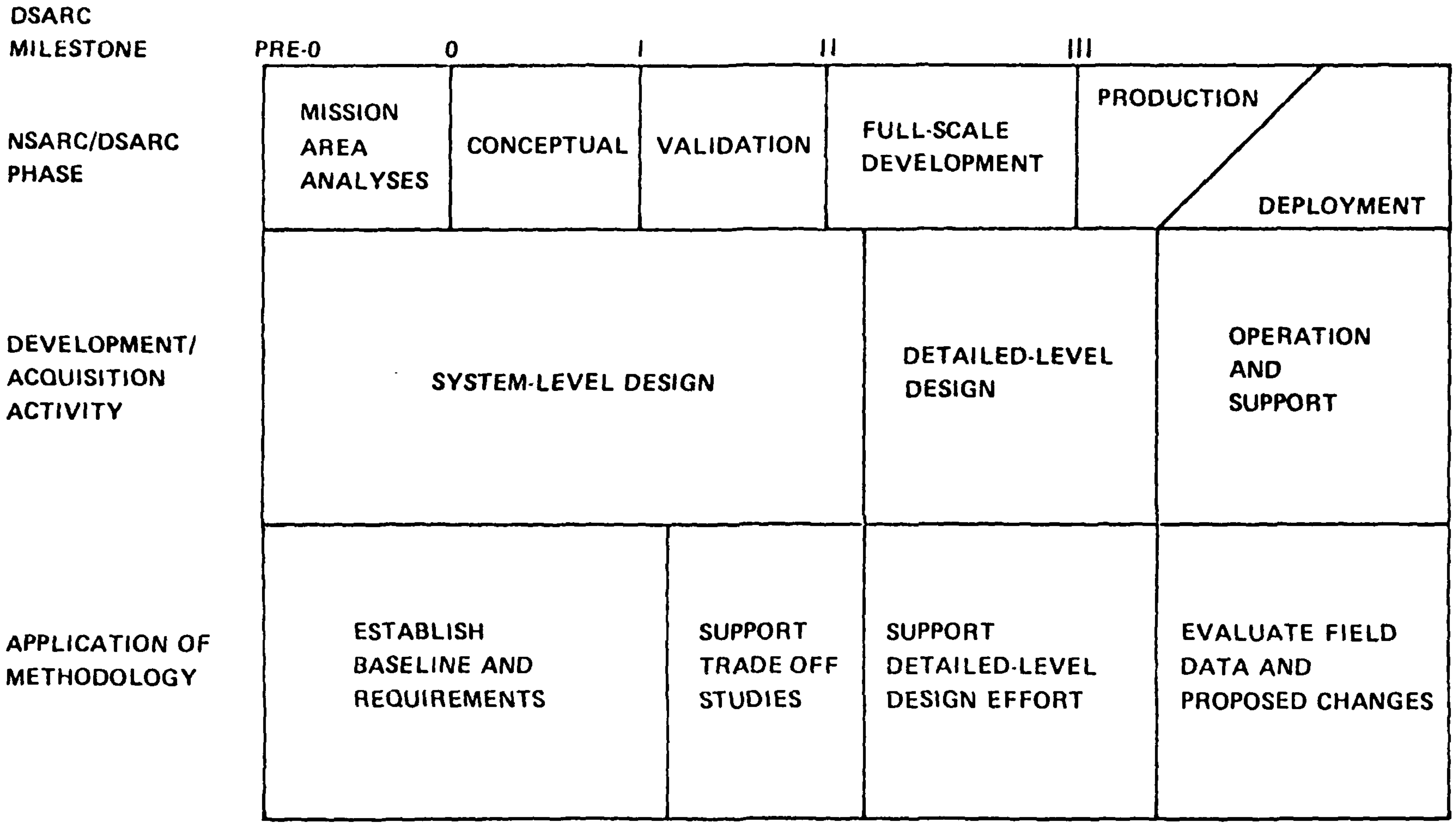


Figure 1. HARDMAN Application in the DSARC/NSARC*

*from DRC, 1980a, p.6

the prototypes are being developed (e.g., the accessibility of a particular part for maintenance). Most of the analysis is performed at milestone one or later, although HARDMAN has been applied before Milestone I.

STEPS IN HARDMAN

HARDMAN has six steps, of which the first four collect, generate, and format data, and the last two evaluate the data (Figure 2).

1. Establish a consolidated data base (CDB)
2. Determine manpower requirements
3. Determine training resource requirements
4. Determine personnel requirements
5. Conduct impact analysis
6. Perform trade-off analysis

The following paragraphs describe the steps and their strengths and weaknesses as they relate to the present research. Full discussions of HARDMAN methodology and applications are available in the references cited at the end of this appendix.

Step 1. Establish a Consolidated Data Base. CDB establishment requires six functions:

1. Determine CDB requirements by collection and review of relevant data, identification of weapon system mission requirements, identification of the acquisition program requirements, and specification of analysis requirements.

2. Identify and select data sources by conducting data source reviews and developing a data source index. An overall data source index is provided in the HARDMAN methodology (DRC, 1980d) and a sample of the listed sources is shown in Figure 3.

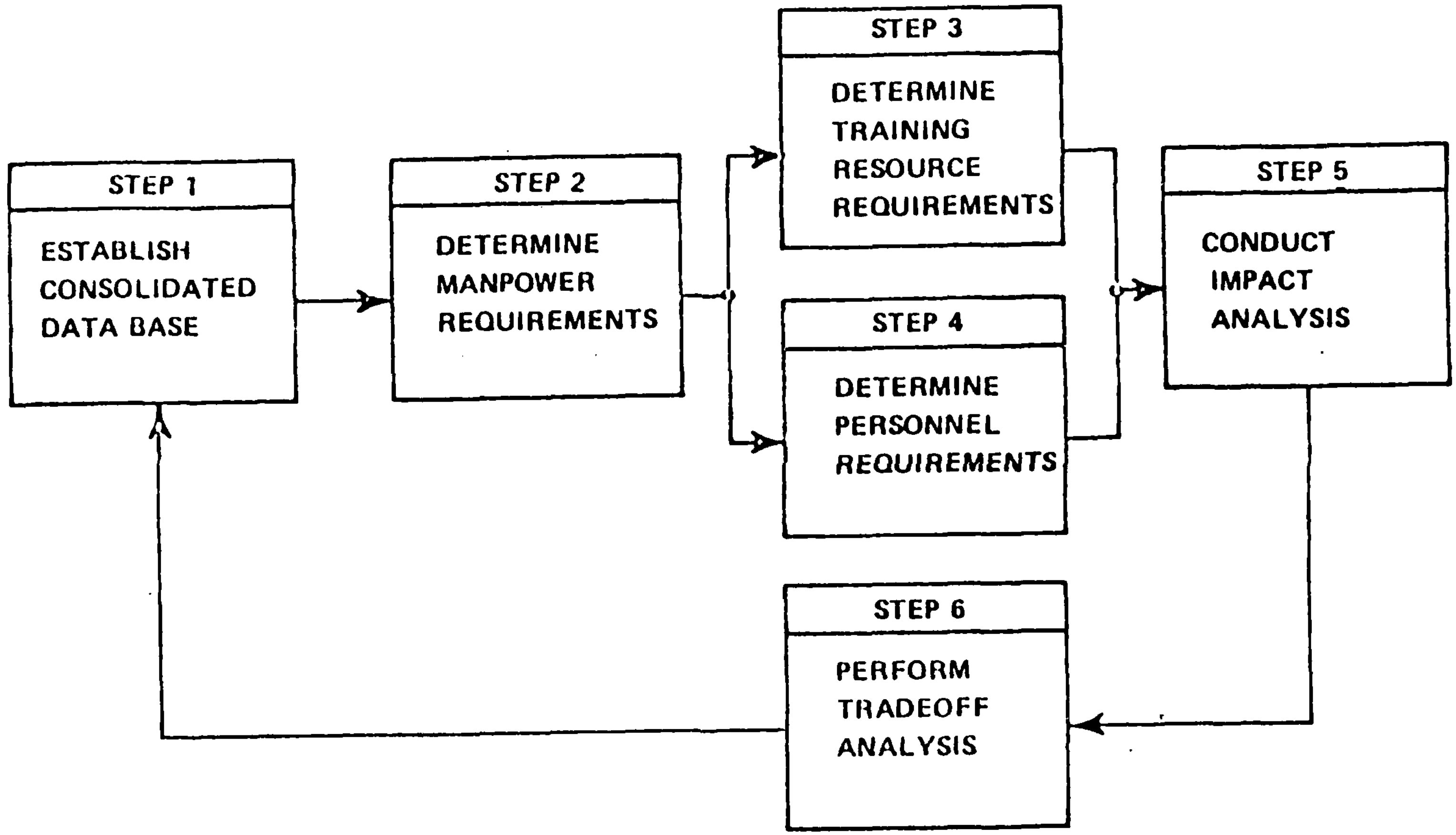


Figure 2. Steps in HARDMAN Methodology*

*from DRC, 1980a, p.9.

3. Establish CDB structure and format by developing data base management structure and producing analysis worksheets and other CDB materials.

4. Perform systems analysis, including the identification of functional requirements of the system and determining the reference system, baseline system and design differences (e.g., equipment improvements, new technologies).

5. Establish and update manpower, personnel, and training (MPT) portions of the CDB.

6. Establish an audit trail of the analyses.

The reference system consists of components and equipment from existing systems that are configured to satisfy the operational and support requirements of the projected system. If an existing predecessor system is performing the missions of the projected system, its subsystems are prime candidates for the reference system. Data from the reference system are modified to reflect the design differences between the reference system and a notional system called the baseline system. The baseline system incorporates low risk technological advances, some of which may exist only in a design stage but are likely to be available before the initial operational capability of the new system. The baseline system, then, consists of real and notional subsystems.

Data are extrapolated from the reference system to form the CDB. Initial CDB input data are derived from documents in the WSAP (as shown in the examples of data sources, Figure 3). The CDB contains data on the reference system, gleaned from historical records such as the maintenance data collection system, maintenance requirement cards, training course outlines, technical manuals, and contractor data. Thus, the method

	Data Requirements					
	Hardware Data	Mission Data	Human Resource Data	Task Data	Cost Data	Training Data
Field Activities: NADC, NWG, NOLC, etc.	x					
Project Offices and/or CNM: NAVSEA, NAV AIR, NAV ELEX	x	x			x	x
Maintenance Support Office Department (MSOD) (3M)	x		x	x		
Navy Ships Parts Control Center (SPCC) (CASREP) (APL)	x					
Weapons Quality Engineering Center (WOEC)	x				x	
Naval Ship's Engineering Center, Norfolk, VA (NAVSECNOR Div.)	x				x	
Government Furnished Information (GFI) Library for System Under Study	x	x	x	x	x	x
Chief of Naval Education and Training (CNET)				x	x	x
Navy Military Personnel Center (NMPC)			x		x	
NAVMMACLANT	x		x	x		

Figure 3. Data Sources for the Consolidated Data Base*
*from DRC, 1980b, p. 35

depends on assumptions made about the reference system; if these assumptions are accurate then the method will be accurate in predicting MPT requirements, especially in the maintenance area. Retaining the accuracy depends on updating as design changes occur. HARDMAN is presently a manual system but appears to be amenable to automation, thus facilitating updating and estimations.

Audit trails for the CDB are maintained on several worksheets, including the design analysis worksheet (Figure 4) and the reliability, maintainability prediction worksheet (Figure 5). Separate worksheets are recommended for each subsystem in the new system.

Step 1 determines the reference and baseline systems, evaluates the impact of their design differences, and establishes the CDB. CDB data include operation and support specifications for the new system, systems engineering information; and manpower, personnel, training, and cost data. The CDB is critical to the HARDMAN methodology and appears to be difficult to establish. For example, the person conducting the work may encounter classified or proprietary data. Performance of the systems analysis (Step 1.4) requires searches of the DoD and NATO inventories that are not in a consolidated form; therefore, the searches are time-consuming and prone to errors of omission. Establishment and update of the MPT portions of the CDB use the same design team as those who design the system. They may not be MPT analysts and thus may discount its importance. The weapon system and MPT data are maintained in separate data bases so that there is a potential problem of the data base interface as well as the engineer and manpower analyst interface. The audit trail (Step 1.6) is one of the strengths of the methodology and will be enhanced if HARDMAN is automated.

DESIGN ANALYSIS WORKSHEET   CATALOG NO.: ______   Sheet ___ of ___

1. Project ______   Function Group ______

System: Predecessor ______   Reference ______   ID No. ______

2. Item(s) Analyzed (circle):

	Name/Nomenclature	WUC/EIC	Manufacturer
System/Subsystem:			
Subsystem/Unit:			
Units/Assemblies (list attached ☐)			

3. Functions/Performance: (see attached ☐)

No. Units: ______ Weight: ______ lb. Volume: ______ ft^3 Input Power: ______ Cost: ______

4. Reliability/Maintainability: Actual/Predicted   Data Source ______

	Subsystem	1. Units (e.g., WRAs)	2.	3.	4.	5.
MTBFailure (Removal):	/					
In Place Repair Probability:	/					
Mean Oper. Time Between Maint:	/					
Scheduled Maintenance:	/					
Mean Time To Repair (On Equip):	/	(shop)				
Support Equipment Required:	/					

5. Configuration change and description: ☐ Substitute ☐ New Design ☐ New Function ☐ Modification ☐ Other

Source of Information: ______

(list items effected including WUCs to the lowest assemblies affected and describe the change)   see attached ☐

6. Effects on Reliability:

see attached ☐

7. Effects on Maintainability: Maintenance Task Networks Completed ☐

see attached ☐

8. Effects on Manpower/Personnel:

see attached ☐

9. Effects on Training:

see attached ☐

10. Effects on Integrated Logistics Support: Maintenance Philosophy: ______   Support ______

see attached ☐

Date: ______   Date: ______   Date ______

11. Analysis Performed by: ______   Reviewed by: ______   Validated by: ______

Figure 4. Design Analysis Worksheet*

*from DRC, 1980b, p. 41

RELIABILITY/MAINTAINABILITY PREDICTION

WORKSHEET

EQUIPMENT NAME ______________________________ ID NO. ______________ CHANGE NO. ______________

- Record predicted influences on R&M parameters and rationale for the selected factors. Parameters of interest include frequency of occurrence (number of maintenance actions) elapsed maintenance time (i.e, MTTR) and MMH (i.e., number techs. per task).

<u>Organizational Level</u>

	TYPE ACTION	NARRATIVE	FACTOR
(01)	CND		
(06)	TBL		
(07)	R & R		
(08)	RIP		
(04)	Cond. R&R		
(05)	Cond. R.I.P.		
(09)	Unspecified		
(02)	Cannibilazation		
(03)	No Defect		
(11)	Unsched. Inspection		
(12)	Corrosion		
(13)	General Support (SAF)		
(10)	Scheduled		

Figure 5. Reliability/Maintainability Production Worksheet*

*from ORC, 1980b, p. 42

Step 2. Determine Manpower Requirements. The second HARDMAN step develops descriptions of the tasks and events for reference system operation and maintenance personnel. The task and event networks are based on the CDB data, mission scenarios, standards on workload categories, and reliability and maintainability data. The HARDMAN user answers a set of questions concerning the maintenance concept for the reference system, operational requirements, specialized support equipment, repair concept, new technology impacts, metrics for system analysis and manpower estimation (e.g., maintenance manhours, cost of operators, billet costs), appropriate models to determine the manpower, and input requirements of the model (Figure 6). The manpower models include the Manpower Determination Model (MDM) and four models in the Navy Manpower Requirements System. Examples of the input requirements include operational requirements, maintenance data, rating and rate, and policy criteria. HARDMAN, therefore, assists the user in providing the input data for a manpower model rather than being a manpower model in itself.

Reliability and maintainability data for the manpower analysis are recorded on worksheets for the reference and baseline systems (Figure 7). Maintenance data are obtained from the maintenance and material management (3M) system where they are found in the maintenance index pages or maintenance required cards. Planned maintenance data are accumulated using operational/maintenance task event networks (Figure 8). The data cover the number of actions and hours for daily, weekly, conditional, and other maintenance schedules. Data to complete the network are obtained from documents such as the organizational or intermediate level maintenance parameters reports (Figure 9). Accumulating the data over the entire task event network produces the workload data for the reference system.

Category	Questions
Maintenance concept for the reference system	1. What are the various maintenance echelons? 2. What are the maintenance tasks performed at each echelon? 3. What are the task sequences? 4. What are the task times? 5. What are the task frequencies?
Specialized support equipment	1. Type? 2. Quantity? 3. Echelon? 4. Used for which tasks?
Repair concept per system/ subsystem	1. Repair levels of various subsystem/removable components? 2. What items are repairable/non-repairable? 3. Failure frequency? 4. Times to repair? Elapsed time? Direct Maintenance Manhours? 5. Maintenance skill and skill level required? 6. Training required (NEC)?
Operation requirement	1. Watch conditions the equipment is operated in? Special conditions? 2. Number of operators required per condition? 3. Skills and skill level required of operators? 4. Training required (NEC)? 5. Number of manhours required for operation? 6. Are operators also maintainers?
What are the impacts of new technology on the reference system	1. Changes in the maintenance concept? 2. Changes in the number of maintenance actions per subsystem? 3. Changes in the mean time to repair? 4. Changes in task times? 5. Changes in skill and skill level requirements of operators? Maintainers? Supervisors? 6. Changes in training requirements (NECs)?

Figure 6. Manpower Data Collection Questions*

*from DRC, 1980b, pp 52-56

Category	Questions
Equipment metrics for system analysis	1. Operational availability? (Ao) 2. Inherent availability? (Ai) 3. Achieved availability? (Aa) 4. Mean Time Between Maintenance? (MTBM) 5. Mean Time Between Failure? (MTBF) 6. Mean Time to Repair? (MTTR) 7. Troubleshooting Time? 8. Maintenance Down Time? (MDT) 9. Average Delay in Maintenance?
Manpower metrics for system analysis	1. Maintenance manhours per equipment operating hour? (MMH/OH) 2. Maintenance manhours per flight hours? (MMH/FH) 3. Cost of Operators per operating hour (flight hour)? 4. Cost of maintenance manpower per operating hour (flight hour)? 5. Maintenance manpower cost per maintenance action? 6. Billet costs?
Model to determine manpower document values	1. Manpower Determination Model (MDM) 2. Navy Manpower Requirements System (NMRS)? ° Ship Manpower Document (SMD) ° Squadron Manpower Document (SQMD) ° Shore Manpower Document (SHMD) ° Shore 3. Interactive Manpower Alternatives Processor (IMAP) 4. SMAS
Input requirements of the	1. Operational requirements (watch requirements)? 2. Maintenance data? ° Planned maintenance times per week? (PM) ° Corrective maintenance times per week? (CM) ° Facility maintenance times per week? (FM) ° Own Unit Support times per week? (OUS) ° Rating, Rate, NEC data? 3. Policy Criteria ° Productivity Allowance (PA)? ° Total hours of work and watch allowed per week? ° Service Diversion (SD) allowance? ° Training allowance? ° Number of watch sections per ship type? ° Length of flight day? ° Conditional watches?

Figure 6. Manpower Data Collection Questions (Continued)

System:		Reference or Baseline	Date:
Subsystem:	Nomenclature:	EIC:	

Data Element	Unit or Mode	Available	Potential Sources
Operating hours	hours		
Operator Rating(s)			
Operator Rate(s)			
No. of Operators	No.		
NEC(s)	4 digit code		
Preventive Maintenance			
• MIPs	Page		
• MRCs	Cards		
• Other			
Organizational Level Data			
– Set up time	hrs/resources		
– Verify time	hrs		
– CND	%		
– Put away time	hrs/resource		
– Close out time	hrs/resource		
– Troubleshooting time	hrs/resource		
– Probability of deferred	%		
• Asst. required	%		
• Parts	%		
• Other	%		
– Probability of completed action	%/hrs		
– Remove and replace actions	%/hrs/resource		
– Disposition of item removed			
– Repair time	%/hrs/resources		
– Condemnation rate	S		

Figure 7. Reliability and Maintainability Worksheet*

*from DRC, 1980b, p. 57

MANPOWER ANALYSIS DATA COLLECTION PLAN
PART I – RELIABILITY AND MAINTAINABILITY DATA

Intermediate Maintenance Level			
– Set up time	hrs/resources		
– Verify time	hrs		
– CND	%		
– Put away time	hrs/resource		
– Close out time	hrs/resource		
– Troubleshooting time	hrs/resource		
– Probability of deferred	%		
• Asst. required	%		
• Parts	%		
• Other	%		
– Probability of completed action	%/hrs		
– Remove and replace actions	%/hrs/resource		
– Disposition of item removed			
– Repair time	%/hrs/resources		
– Condemnation rate	S		
Depot Level			
– Set up time	hrs/resources		
– Verify time	hrs		
– CND	%		
– Put away time	hrs/resource		
– Close out time	hrs/resource		
– Troubleshooting time	hrs/resource		
– Probability of deferred	%		
• Asst. required	%		
• Parts	%		
• Other	%		
– Probability of completed action	%/hrs		
– Remove and replace actions	%/hrs/resource		
– Disposition of item removed			
– Repair time	%/hrs/resources		
– Condemnation rate	S		

Figure 7. Reliability and Maintainability Worksheet
(continued)

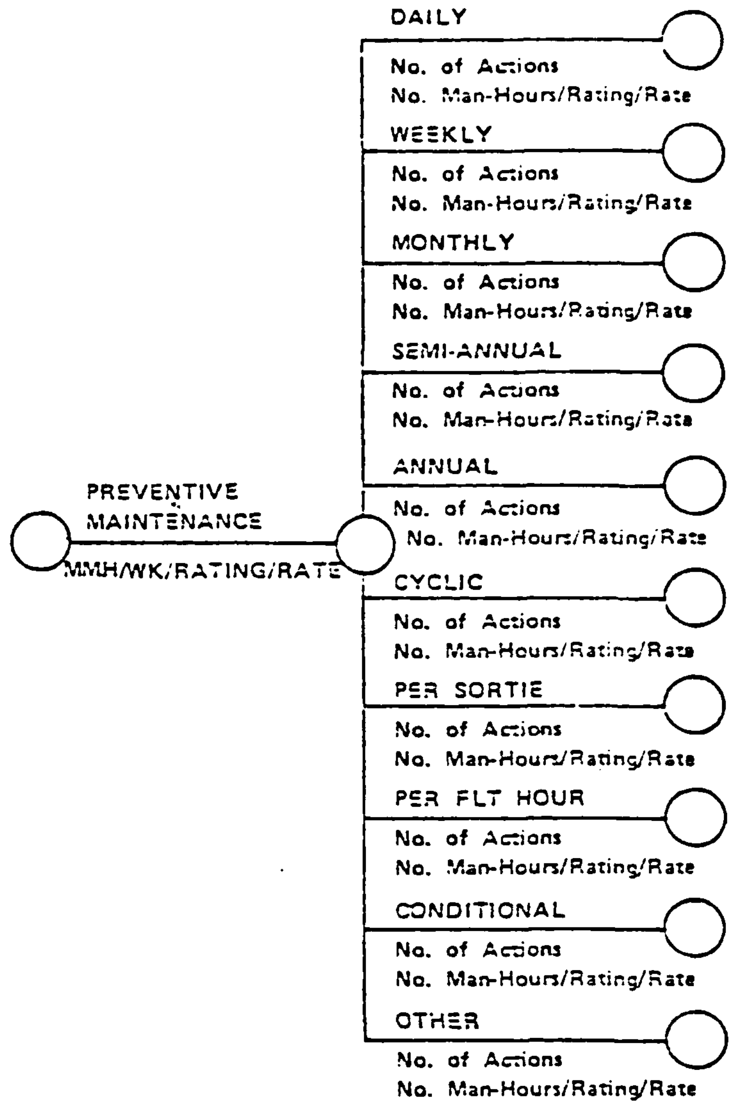


Figure 8. Operational/Maintenance Task Event Networks; Planned Maintenance Data*

*from DRC, 1980b, p. 67

AVERAGE ELAPSED MAINTENANCE TIME
****TA4J AIRCRAFT (01,11,21,31 RECS) 1/76-12/78 - FLIGHT LINE WDCS -

UNSCHEDULED REPAIR

NAME	TRBLE SHOOT	CND	COND R&R	R&R	COND RIP	RIP	UN-SPEC	TOTAL
INSPECT	0.	0.	0.	0.	0.	0.	0.4	0.4
CORROSI	0.	0.	0.	0.	0.	0.	0.	0.
AIRFRAM	3.1	0.8	2.0	0.4	0.4	2.9	2.8	0.6
FUSELAG	1.0	0.8	1.6	0.9	0.7	2.8	0.	0.9
LANDING	3.4	1.0	0.2	0.3	0.4	3.0	1.1	0.6
FLIGHT	9.5	1.0	2.8	0.3	0.4	6.1	3.0	1.2
TURBOJE	6.0	1.6	9.6	0.4	0.5	13.1	6.4	2.8
POWER P	1.9	1.1	2.5	0.4	1.1	3.2	1.0	1.1
AIR CON	2.1	1.1	3.2	1.9	1.0	3.3	0.	1.8
ELECTRI	7.9	1.2	3.1	0.5	0.5	4.2	8.0	1.3
LIGHT S	6.1	0.8	1.0	0.2	0.8	1.2	1.0	0.5
HYDRAUL	1.8	1.2	5.1	0.5	0.8	4.5	0.	1.1
FUEL SY	9.4	1.3	2.1	0.6	1.0	4.7	0.	1.4
OXYGEN	1.1	0.7	1.0	1.0	0.8	1.1	0.8	1.0
MISCELL	0.	0.8	0.	1.2	0.9	4.0	0.	1.3
EMERGEN	0.5	0.5	0.9	1.0	0.8	1.1	1.0	0.9
PERSONN	0.8	0.6	1.0	1.0	0.8	1.5	0.	1.0
EXPLOSI	1.0	0.9	1.7	2.1	1.0	1.3	0.	1.8
UNKNOWN	0.	1.0	0.9	1.5	0.9	2.4	0.	1.3
FLIGHT	3.8	1.1	1.8	0.3	1.4	2.0	0.	1.2
ENGINE	4.6	1.4	2.4	1.4	1.0	3.1	0.	2.2
NAVIGAT	0.4	0.9	0.	1.1	0.9	2.0	0.	1.2
C-8 COM	0.	1.2	0.	2.3	0.5	3.2	0.	2.0

Figure 9. Sample Organizational Level Maintenance Parameters Report*
*from DRC, 1980b, p. 75

The next process is analysis of the difference between the reference and baseline systems. A set of guidelines is used to determine the impact of technological improvements and design differences (Figure 10). The questions pertain to the physical features, design features, system concepts (e.g., interface/intercommunications, maintenance and operations concepts.) Answers to the questions produce estimates of the human resources for the baseline system. Perturbations of the values are determined and applied to the task and event network for the reference system. For example, if the use of composite materials for corrosion control generates a 25 percent reduction in manhours, this factor is used to correct the parameters for the baseline system.

Measures used in HARDMAN as the equipment and manpower metrics are shown in Figures 11 and 12. Manpower metrics can be computed from data in the CDB. Manpower requirements for the new system are determined by application of one of the manpower models listed above.

In summary, the activities in Step 2 are to establish the manpower portion of the CDB, model operation and support actions; determine the system metrics, and select and run a manpower model. These activites are inherently vague and subjective. For example, estimates are made of time devoted by operators and maintainers; however, an operator may have an hour of continuous work with the system while the maintainer devotes an hour over a period of days or weeks. They spend the same amount of time on the equipment, but the MPT implications differ. The determination of workload categories (Step 2.1.1) is influenced by differences in time estimation terminology and the procedure for it is being modified to allow for discrepancies in time estimates.

A. Technological Concepts and Equipment Characteristics

Category	Characteristics	Questions
Physical features	Size, weight, volume, number of units	What are the changes made in this area?
	Location	Where are the subsystem units physically located (personnel required may be affected if the units are spread out)?
Design features:	Electronic design	New devices/components: What is the electronic state-of-art proposed for the baseline subsystem? What is the level of internal functional integration?
		Digital/analog: What functions are digital or analog? What are the interfaces?
		Modularity: What is the level of modular constructions? What percentage of the sub-system is modular? To what extent is the modularity standarized (SEM)?
	Mechanical design	Accessibility: How long does it take operational/maintenance (O/M) personnel to open inspection ports or to get into a unit?
		Complexity of moving major assemblies: What types of SE are required to move units? How easy is SE to set up? To use?
		Tolerances? How many procedures require alignment/ adjustment to a given tolerance? How critical are the tolerances? How easy is it to achieve the given tolerance specifications?

Figure 10. Guidelines for Technological Improvements and Design Differences*

*from DRC, 1981c, pp. 79-87

A. Technological Concepts and Equipment Characteristics (Continued)

Category	Characteristics	Questions
	General design characteristics	Special tools: What special tools are required? How complex are they to use?
		Special purpose test equipment (SPTE): What SPTE is required? How complex is it to use? What are its capabilities?
		Built in test equipment (BITE): What BITE exists? What are its capabilites? How long to test? How effective?
		Modularity: What is the level of modular construction? What percentage of the subsystem is modular? To what extent is the modularity standardized (SEM)?
Interface	Software	How compatible is software between the subsystems?
	System hardware integration	To what extent do various subsystems share hardware functions such as controls and displays?
	Central integrated test system (CITS)	To what extend does CITS exist? What are its capabilities?
	Computer-aided instruction (CAM/I)	To what extent does CAM/I exist?
	Bussing	What type of bus system exists?
Maintenance	Organizational	What is the maintenance concept at the organizational level?

Figure 10.
Guidelines for Technological Improvements and Design Differences* (Continued)

B. System-Related Concepts

Category	Characteristics	Questions
	Intermediate	What is the maintenance philosophy for the given subsystem at this level?
	Depot	What functions does the depot activity provide in support of the subsystem?
		Are Navy personnel involved? Civil Service? Contractor?
		What support (spares, etc.) does the depot provide for the subsystem and what are the resultant manpower needs?
	Operational concept	Does the subsystem require operational manning?
		What is the manning frequency/period?
		What are the operational tasks required? What are the operational checks required?
		Where is the subsystem operated from? Remote? Local? More than one location simultaneously?
		What is the operator task loading? Human engineering factors?

Figure 10.
Guidelines for Technological Improvements and Design Differences* (Continued)

EQUIPMENT METRICS	TERM	REMARKS
1. Operational Availability	A_o	$A_o = \frac{MTBM}{MTBM + MDT}$
2. Inherent Availability	A_I	$A_i = \frac{MTBF}{MTBF + MTTR}$
3. Achieved Availability	A_a	$A_a = \frac{MTBM}{MTBM + M}$
4. Mean Time Between Maintenance	MTBM	
5. Mean Time Between Failure	MTBF	
6. Mean Time To Repair	MTTR	CM Time Only
7. Troubleshooting Time		
8. Maintenance Down Time	MDT	
9. Average Delay in Maintenance		Deferred Actions
10. Mean Active Maintenance Time	M	CM + PM Times

Figure 11. Equipment Metrics*

*from DRC, 1980b, pp 90-91

MANPOWER METRIC	TERM
1. Maintenance Manhours per Equipment Operating Hour	MMH/OH
2. Maintenance Manhour per Flight Hours	MMH/FH
3. Cost of Operators	$Cost_o$
4. Cost of Maintainers	$Cost_m$
5. Maintenance Manpower Cost per Maintenance Action	
6. Billet Cost	$Cost_b$

Figure 12. Manpower Metrics*

*from DRC, 1980b, p. 93

Establishment of the reference system task network relies on two data sources. One is the Navy Occupational Task Analysis Program (NOTAP) which contains data on personnel and task analytic factors; these data appear to be acceptable to those working in the area. The second source is field data stored at the Navy facility at Mechanicsburg, PA. These data relate to system maintenance and the people working in the MPT area do not seem to consider them to be accurate.

Selection of the manpower model (Step 2.4.1) currently depends on where the analyst is located. Navy departments (NAVMACLAND, NAVAIR, NAVSEA) have their own models and so apply the one available to them. The implementation of HARDMAN across the Navy will help standardize the selection of the model. Also, implementation may result in running the models early in the acquisition cycle where the results may have more impact on design than they do now.

Step 3. Determine Training Resource Requirements. Training Resource Requirements Analysis (TRRA) provides estimates of the resources and costs of training the operational and maintenance personnel for the predecessor, reference, and baseline system within the following limits:

1. Estimates are based on available data and are iterated during the WSAP.

2. Resources and costs are estimated for average or steady-state conditions.

3. Training not estimated includes that in operational tests of the system, factory training, and new equipment training.

4. Formal school training resources and costs are estimated but not on-the-job (OJT) training.

5. Civilian and officer training is not estimated.

6. Training estimates are made only for those who directly operate and maintain the subsystems related to baseline design impacts.

7. The need for new construction is identified but the resources are not estimated.

In general, TRRA provides estimates of training resources and costs for use in early design trade-offs (e.g., pre-milestone 0 and the conceptual phase) and estimates for the training developer to use to design the training (as the concepts are defined late in the conceptual phase and onward). The intent is to focus on the former; i.e., the early estimation for design trade-offs.

The earliest TRRA application is at a general level in which very general task and skill data are used, baseline media are determined by analyzing existing courses, and the process produces quick results. It is not appropriate for detailed training development information such as the Army's Instructional Systems Development (ISD) model.

The three major activities in this step are to establish the training portion of the CDB, document training programs for the predecessor, reference, and baseline systems and determine additional training requirements. In the first activity block diagrams are produced that depict the reference, predecessor, and baseline equipment systems. The baseline diagrams focus on the new and modified equipment; i.e., those that differ from the reference and predecessor systems. Existing training courses are identified for the reference and predecessor systems, and the most closely related training is identified for the new or modified components. The latter are analyzed in more detail in subsequent steps.

AD-A148 642 MANPOWER AND PERSONNEL REQUIREMENTS DETERMINATION 3/4
METHODOLOGIES (MANPERS)(U) GENERAL RESEARCH CORP MCLEAN
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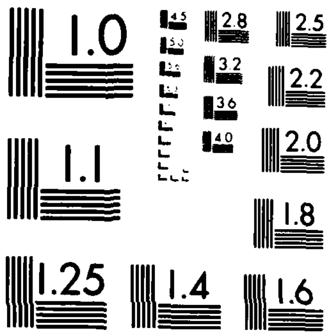
UNCLASSIFIED ARI-RN-84-136 MDA903-82-C-0269 F/G 5/1 NL



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963 A

Tasks in the relevant existing training programs are analyzed in the second part of this step, particularly the tasks in the reference system training. The tasks are categorized according to their action verbs; the verb lists for corrective maintenance, planned maintenance, and operator tasks are shown in Figure 13. The task action verbs are further analyzed according to the Army's ISD, using the eleven (11) task categories from Braby, Henry, Parrish and Swope (1975). Other input data include:

1. Reference and Baseline Equipment Lists
2. Baseline Design Differences
3. Baseline Operator and Maintainer Task Event Descriptions
4. Baseline Skills and Knowledge List
5. List of Reference Tasks Trained
6. Reference Training Setting Information
7. Reference Training Methods Information
8. Reference Training Media Information
9. Task Characteristic Ratings
   - Difficulty
   - Importance
   - Frequency
   - Visual Cues Importance
   - Auditory Cues Importance
   - Coordinated Kinesthetic Cues Importance
   - External Scenario Cues Importance
   - Importance of Sequential Relationships
   - Simulation Capability of Actual Equipment
   - Direct Equipment Interface
   - Integrated Performance with Other Operators

Category	Questions
Corrective Maintenance	Set up (support equipment) Verify/test Remove and replace Troubleshoot Adjust/align Repair (bench check and repair)
Planned Maintenance	Inspect Remove and replace (minor parts) Adjust/align Lubricate
Operate	Activate/deactivate Monitor Track Steer Pilot Drive Load Aim/fire Communication Assess/decide

Figure 13. Action Verbs for Corrective Maintenance, Planned Maintenance, and Operation*

*from DRC, 1980d, pp. C4, 5, and 6

- Likelihood of Injury to Operator
- Likelihood of Harm to Equipment
- Physical Restrictions of Actual Equipment
- Expensiveness of Actual Equipment
- Part Task/Whole Task
- Number of Decision Rules
- Simulation Capability of Actual Equipment
- Learning Categories

TRRA determines general media types; for example, it distinguishes print, part task trainers, whole task trainers, weapon system trainer, and actual equipment trainers (Figure 14). It does not analyze the details of characteristics or features within these general types of media. Improvements for TRRA are in progress and may provide methods in more detail.

One activity in this Step has implications for qualitative personnel estimates as well as training estimates. The procedures for determining baseline impacts on tasks use the difference between the predecessor/reference system tasks and the baseline tasks to estimate the magnitude of design changes on corrective maintenance, planned maintenance, and operator tasks (Figures 15, 16 and 17). Examples of the data estimated are mean time between failures (MTBF), test equipment accuracy and useability, percent of time performing, and number of operators. These differential impacts are used to structure tasks within a billet, determine the need for a new billet and determine changes required in training.

MEDIA TYPES	Rule Learning/ Using	Classifying Recognizing Patterns	Identifying Symbols	Detecting	Making Decisions	Recalling Knowledge	Performing Gross Motor Skills	Steering, Guiding Continuous Movement	Positioning Movement/ Recalling Procedures	Voice Communi-cation	Attitude Learning
Print	x	x			x	x			x		x
Audio—Only		x		x		†					
Audio-Visual Static		x	x			†			x	†	†
Audio-Visual Dynamic		x	x	x	†	†					
Mockups, Panels, Demonstrators—Static		x	x		x				x		
Mockups, Panels, Demonstrators—Dynamic	x	†	x	x	x				x		
Simulator-Part Task	x	†	x	x	x		x	x	x		
Simulator-Whole Task	x			x	x		x	x	x	x	
Weapon System Trainer	x			†	x		x	x	x	x	
Operator System— without Simulation	x	†		x	x		x	x	x	x	
Operator System with Simulation	x	†		x	x		x	x	x	x	
Computer Simulation	x				x				x		
Computer-Assisted Instruction	x	x	x		x	x					

x = high probability that learning category will require media type during formal school training

† = learning category may occasionally require media type during formal school training

Figure 14. Media Types for Learning Categories*

*from DRC, 1980d, p. D-22

DESIGN CHANGE NO. ______________ EQUIPMENT NOMENCLATURE ______________ WUC ______________

TASKS AND TASK PARAMETERS

Design Factors (Increase in . . .)	Set Up Support Equipment			Verify/Test				Remove and Replace				Troubleshoot				Adjust/Align				Repair (WRA-Level)			
	Duration	Frequency (Probability)	No. of People	Duration	Frequency (Probability)	No. of People	Support Equipment Type	Duration	Frequency (Probability)	No. of People	Support Equipment Type	Duration	Frequency (Probability)	No. of People	Support Equipment Type	Duration	Frequency (Probability)	No. of People	Support Equipment Type	Duration	Frequency (Probability)	No. of People	Support Equipment Type
MTBF		---			---				--				---				—				—		
Accessibility				---		--		---		---		—		—		---		---					
No. of Components/ Modules	+		+	++	+	+	V	+	+	+		+++	+	++	VV	++	+	+		+++	++	++	VVV
System Complexity (No. of Interfaces)	+		+	++	+	+	V	+	+	+		+++	+	++	VV	++	+	+		+++	++	++	VVV
Automated Fault Localization (e.g., BITE)	—											---	+	---	VV					—		—	VV
Standardization of Components	—							--		—		—		—	VV	—		—	V	—		—	VV
Test Equipment Accuracy				—	---	—						—	—	—	V	—	—	—			—		
Test Equipment Usability				—	---	—						—	---	·	V	—	—	—			—		
Automated Performance Monitoring				---	---	...	VV																
Accuracy of Job Performance Aids				—		—		—		--		---		—		—		—		—		—	

+++ (---) = estimated to have large positive (negative) impact on task parameter

++ (--) = estimated to have moderate positive (negative) impact on task parameter

+ (—) = estimated to have small positive (negative) impact on task parameter

V = change in support equipment type number of checks indicates degree of change

Figure 15. Matrix for Determining Magnitude of Design Impacts on Corrective Maintenance*

from DRC, 1980d, p. C-14

DESIGN CHANGE NO. ____________ EQUIPMENT NOMENCLATURE ________________ WUC ____________

TASKS AND TASK PARAMETERS

Design Factor (Increase in . . .)	Inspect				Remove/Replace				Adjust/Align				Lubricate		
	Duration	Probability (Frequency)	No. of People	Support Equipment Type	Duration	Probability (Frequency)	No. of People	Support Equipment Type	Duration	Probability (Frequency)	No. of People	Support Equipment Type	Duration	Probability (Frequency)	No. of People
MTBF (Minor Parts)		---				–				---				–	
Automatic Performance Monitoring	---	–	---	VVV					–	--	–	VV			
Accessibility					---		---	VVV	---		---				
No. of Components Modules	++		++	VV	+	+	+		++	++	++	VV	++	++	+
Test Equipment Usability	--		--		--		--								
Standardization of Components	–		–		--		–	VV	--		--				
Lubricant Quality													---	---	---

+++ (---) = estimated to have large positive (negative) impact on task parameter

++ (--) = estimated to have moderate positive (negative) impact on task parameter

+ (–) = estimated to have small positive (negative) impact on task parameter

V = change in support equipment type. Number of checks indicates likely degree of change.

Figure 16. Matrix for Determining the Magnitude of Design Impacts on Planned Maintenance Task Parameters*

*from DRC, 1980d, p. C-15

Task Parameter	Major Factors Providing Parameter Changes: Non-Design Factors	Design-Related Factors
INPUT PARAMETERS		
• Number	System Mission System Scenario	Degree of Partial Task Automation
• Type	System Mission System Scenario	Partial Task Automation
• Medium	-	Direct Design Option
• Frequency	System Mission System Scenario	Degree of Partial Task Automation; Adequacy of Human Factors Design
CONTROL PARAMETERS		
• Number	System Mission System Scenario	Degree of Partial Task Automation
• Type	System Mission System Scenario	Partial Task Automation
• Medium	-	Direct Design Option[1]
• Frequency	System Mission System Scenario	Control Medium; Adequacy of Human Factors Design
COMMUNICATION PARAMETERS	-	
• Number	System Mission System Scenario	Degree of Partial Task Automation
• Type	System Mission System Scenario	Degree of Partial Task Automation
• Medium	System Scenario	Direct Design Option
• Frequency	System Mission System Scenario	Communication Medium; Adequacy of Human Factors Design
DECISION-MAKING PARAMETERS		
• Number of Problems	System Mission System Scenario	Degree of Partial Task Automation
• Types	System Mission System Scenario	Partial Task Automation
• Frequency	System Mission System Scenario	Degree of Partial Task Automation; Adequacy of Human Factors Design
STANDARD PARAMETERS		
• % of Time Performing	Manning Policy System Mission, System Scenario	Degree of Partial Task Automation Maintenance Task Requirements
• No. of Operators	Manning Policy	Degree of Partial Task Automation Adequacy of Human Factors Design Maintenance Task Requirements

Figure 17. Guidelines for Determining the Impact of Design Parameters on Operator Task Parameters*

*from DRC, 1980d, p. C-16

Step 4. Determine Personnel Requirements. Personnel requirements analysis builds on the task analysis for qualitative personnel estimates in TRRA, interacts with the CDB-building in Step 1, and determines the qualitative and quantitative characteristics of personnel to sustain the manpower requirements determined in Step 2. Three activities in personnel requirements analysis are establishment of the personnel portion of the CDB, personnel pipeline flow characteristics, and final personnel requirements.

The first activity, establishment of the personnel portion of the CDB, includes identification of data requirements and sources, collection and formatting of the data, and setting up an audit trail. The audit trail is manual and worksheets are provided. Some examples of data requirements and supporting data elements are shown in Figure 18. Major sources of data are the TRRA (e.g., the task analysis) and Navy's Enlisted Master Records (EMR); the latter provide data on individual social security number, sex, rate/rating, time in pay grade, active duty service date, enlistment information, sea and shore duty commencement dates, and other demographic information.

The second activity, establishment of personnel pipeline flow characteristics, uses a tracking procedure that follows each individual from one data period to the next to determine: active/inactive status, rating/rate, and sea/shore location.

These data are summarized to represent: advancement/attrition probabilities for each career path within each rate, average times-in-rate for each career path within each rate, and sea/shore rotation and tour lengths for each rating by sex.

OUTPUTS	PURPOSE	SUPPORTING DATA ELEMENTS
Required: Advancement and attrition probabilites for all rates within ratings	To calculate the probability of being in a particular rating/rate based on the probability of what it takes to get there.	Social security number abilities. Strength (active/inactive). Rating/rate. Date of entry to paygrade. Primary/secondary NECs.
Sea/shore tour overall, male, and females.	To be able to subtract out non-assignable time (e.e., if a person's services are required on a ship, time spent on shore is non-assignable time).	SSN. Strength (active/inactive). Sea/shore status. Sea/shore duty start date. Rating/rate primary/second NECs. Sex.
Average lengths of time-in-rate for all rates within ratings.	To calculate the average time to "grow" a person to a particular level of rating/rate.	Social security number. Strength (active/inactive). Rating/rate. Date of entry to paygrade. Primary/secondary NECs.

Figure 18. Personnel Data Requirements*

*from DRC, 1980b, pp. 180-181

OUTPUTS	PURPOSE	SUPPORTING DATA ELEMENTS
Average effective lengths of time-in-rate for all rates within ratings.	This denotes that time spent in non-assignable activity (in school, on shore or sea depending on the weapon system) is subtracted out of actual lengths of time.	Social security number. Strength (active/inactive). Rating/rate. Date of entry to pay grade. Primary/secondary NEC. Limited duty designator. Sea/shore duty status and start date. Accounting category. School history.
Career path probabilities.	To establish the predominant sequences of schools a person attends.	SSN. School history. Active duty start date.
Report of numbers of personnel by rating/rates & NECs.	To analyze fluctuations in the number of people by rating/rate.	SSN. Rating/rate. Primary/secondary NECs.
Costs.	To determine personnel costs for use in comparing predecessor, reference, baseline costs.	Cost of pay for rates. Cost of training.

Figure 18. Personnel Data Requirements (Continued)

The first pipeline flow characteristics are determined for the reference system and thus represent the current personnel system (career paths, advancement and attrition probabilities, average times-in-rate, and sea/shore rotations). Second, the reference system career paths are modified to reflect differences between the reference and baseline systems. The differences are largely in the manning requirements, career paths and training course lengths and kinds. The present user's manual does not provide detailed questions for this discrepancy analysis.

The final activity in this step is determination of personnel requirements. HARDMAN applies a minumum flow solution model to the pipeline data and a cost model.

In summary, personnel requirements are determined by identifying and collecting data for the CDB, analyzing the personnel pipelines for the reference and baseline systems, and computing minimum flow solutions and personnel costs. Determination of personnel characteristics requires projections from historical data. The projections are difficult if a new rating is needed (e.g., task inventories do not exist for the new rating). The problem is compounded in establishment of the pipeline flow (Step 4.2.1) where coordination is needed among commands responible for the personnel flow. Thus, it is easier to project personnel for existing ratings than to establish new ones.

HARDMAN, if applied early in the WSAP, can help with a current problem in personnel pipeline determination. Given the unique nature of military, especially combat, jobs the military must develop rather than recruit, or "hire" senior enlisted personnel (NCOs). For example, to prepare one E6 for a unique military system, the military must recruit 100 new personnel six years earlier, train them, and move them through the personnel pipeline. The extent of planning has increased as more personnel are needed at senior levels to operate and maintain high-technology weaponry. These senior personnel will not be available unless they are projected, procured, trained and advanced. HARDMAN personnel projections, which are made for all levels of personnel, can provide the planning to enable these personnel to be ready.

Step 5. Conduct Impact Analysis. This step is presented in outline form in the user's manual since it has not yet been validated. It determines the Navy's supply of training and manpower resources required by a proposed system, determines the MPT demand of the proposed system, and compares them to the projected supply. The goal is to highlight new requirements for skills, training, and training resources; design and other drivers of high human resource demands; need for scarce assets, and high cost components of the MPT system.

Step 6. Perform Trade-off Analysis. Like Step 5, this step has not been validated and is presented in outline form. The activities are consolidation of critical requirements and sources, identification of potential solutions, and iteration of the procedures to analyze proposed solutions.

APPLICATIONS AND IMPLEMENTATION

The HARDMAN development office in the Office of the Chief of Naval Operations (OP-112C) manages the development, application, and implementation of HARDMAN. Applications have been performed by the developer, Dynamics Research Corporation, and by Pacer Systems. Personnel who apply HARDMAN typically have had military experience, have engineering backgrounds and have performed task analysis in the past. They hold positions equivalent to government service grades 9 and 11 and are supervised by personnel who hold positions equivalent to grades 12 to 14. They identify reference and baseline systems based on their experience; the process appears to be somewhat of an art form.

The method has subjective validity since it has been applied to several systems with apparent success, but it has not been empirically validated. The Navy and Army systems to which HARDMAN has been applied are the following:

1. Shipboard Intermediate Range Combat System (SIRCS)
2. Landing Ship Dock (LSD-4) propulsion system
3. Advanced Light Weight Torpedo
4. A new destroyer class (DDGX)
5. Undergraduate Jet Flight Training System (VTXTS)
6. Corps Support Weapon System (CSWS)
7. Division Support Weapon System (DSWS, in progress)
8. Single Channel Ground-Airborne Radio System (SINCGARS)
9. Remotely Piloted Vehicle (RPV, in progress)

HARDMAN is the predominant method used by the Navy for MPT estimation. Other models are used (e.g., the manpower estimation models cited in Step 2 of HARDMAN) but they are piecemeal approaches for projecting manpower requirements. The Navy plans to make HARDMAN the official Navy method for MPT analysis in the acquisition process in Fiscal Year 1985. The HARDMAN development office has planned the implementation so that the method will be used throughout the Navy by that time.

REFERENCES

Braby, R., Henry, J. M., Parrish, W. F., r., & Swope, W. M. A technique choosing cost-effective instructional delivery systems (TAEG report No. 16). Orlando, FL: Department of the Navy, Training Analysis and Evaluation Group, 1975.

Dynamics Research Corporation. <u>HARDMAN methodology handbook volume I: Executive summary</u>. Wilmington, Mass: Author, 1980 (a)

Dynamics Research Corporation. <u>HARDMAN methodology handbook volume II: Users' manual preliminary draft</u>. Wilmington, Mass., Author, 1980(b).

Dynamics Research Corporation. HARDMAN methodology handbook volume III: Summary diagrams. Wilmington, Mass: Author, 1980 (c).

Dynamics Research Corporation. HARDMAN methodology handbook volume IV: Appendixes. Wilmington, Mass: Author, 1980 (d).

Dynamics Research Corporation. <u>Application of the HARDMAN methodology to the Undergraduate Jet Flight Training System (VTXTS) Volume I: Technical Report</u>. Wilmington, Mass: Author, 1981 (a).

Dynamics Research Corporation. <u>Application of the HARDMAN methodology to the Undergraduate Jet Flight Training System (VTXTS) Volume II: Appendixes</u>. Wilmington, Mass: Author, 1981 (b).

Dynamics Research Corporation. <u>Application of the HARDMAN methodology to the Undergraduate Jet</u>. <u>Flight Training System (VTXTS) Volume III</u>: HARDMAN methodology handbook -- Users' manual (preliminary draft). Wilmington, Mass: Author, 1981 (c).

APPENDIX B

Russel E. Schulz

REVIEW OF AIR FORCE METHODS FOR DETERMINING MANPOWER REQUIREMENTS

Contents

REVIEW OF AIR FORCE METHODS FOR DETERMINING MANPOWER REQUIREMENTS

INTRODUCTION

The Air Force's methods for determining the qualitative and quantitative manpower requirements for operator and maintenance personnel were reviewed to determine relevance for ARMPREP. The review covered the methods in current use, the agencies involved, and a recent development effort, the Acquisition of Supportable Systems Evaluation Technology (ASSET). While these methods were found promising for Air Force systems, they would require considerable adaptation to be applicable for ARMPREP requirements. Such adaptation is not recommended as a part of ARMPREP.

AIR FORCE ORGANIZATIONAL STRUCTURE FOR NEW WEAPON SYSTEM ACQUISITION

Air Force Systems Command

The Air Force Systems Command commander at Andrews AFB, MD, has ultimate responsibility for weapon system acquisition. The actual acquisition takes place at one of the five product divisions:

1. Space and Missile Systems Organization, Los Angeles AFB, CA
2. Aeronautical Systems Division, Wright-Patterson AFB, OH
3. Electronic Systems Division, Hanscom AFB, MA
4. Aerospace Medical Division, Brooks AFB, TX
5. Armament Development and Test Center, Eglin AFB, FL

A System Program Office (SPO) is established at the product division designated for weapon system acquistion. The SPO is the office of the program manager and is the single point of contact with industry, government agencies, and other activities participating in the system acquisition process.

Other Major Participants

Other major participants in the acquisition process are the operating command, Air Force Logistics Command (AFLC), Air Training Command (ATC), and Air Force Test and Evaluation Center (AFTEC). The roles of each of these are briefly described below:

Operating Command. The major command (e.g., Strategic Air Command, SAC) which will operate the system, subsystem, or item of equipment being acquired has responsibilities which include mission area analysis, need identification, Statement of Operational Need (SON) preparation, and operational testing. In terms of manpower and personnel requirements, the operating command establishes the maintenance concept for the proposed system; this describes maintenance requirements and is a basic part of the framework upon which system logistics planning is based.

Air Force Logistics Command (AFLC). One of the key organizations within AFLC is the Air Force Acquistion Logistics Division (AFALD). AFALD, under AFLC direction, assumes total management responsibility from the Air Force Systems Command for identifying logistics requirements; participating in source selection; developing the maintenance concept; assisting in the management of the design, development, and testing; spares provisioning; and ensuring reliability, maintainability, and support considerations. The Deputy Program Manger, Logistics (DPML) is the AFLC representative in the System Program Office.

Air Training Command (ATC). ATC participates in the total acquisition process. It provides inputs to the SON and ensures that training is considered in the design and development of the system and in the system operation concept and plans. ATC also develops the training concept, including proposed contractor training, AF training, training facilities, and training aids.

It is responsible for maintenance training support from initial implementation through the life cycle of the system. Contract flight training or simulator aircrew training may also be an ATC responsibility.

MANPOWER REQUIREMENTS FOR NEW WEAPON SYSTEM ACQUISITION

Air Force and civilian personnel at Air Force Systems Command Headquarters, the Aeronautical Systems Division, and Electronic Systems Division were informally surveyed concerning methods used by the Air Force for determining the qualitative and quantitative manpower requirements for new systems being acquired by the Air Force.

In general, it was found that the QQPRI as employed by the Army is seldom or never used in the Air Force. Rather, the Air Force tends to rely on a "beefed-up" version of the LSAR for their QQPRI inputs. However, in the acquisition of some smaller Air Force systems, contractors are required to provide QQPRI-type data as part of their proposal. These data, which are usually estimates, are one basis for contract award. They are probably not sufficiently accurate for other uses.

However, in acquiring most Air Force weapon systems, and especially large aircraft weapon systems, a more systematic approach is taken to determine the qualitative and quantitative manpower requirements of the new system. Information gained from the survey relevant to the qualitative requirements and the quantitative requirements is summarized below.

Qualitative Manpower Requirements

The first information provided as to the type of personnel required to operate and maintain a new weapon system is provided by the contractor. Under normal circumstances the contractor is charged with performing an operational and maintenance task analysis. Even though the major emphasis in this analysis is the determination of quantitative requirements, part of the task analysis relates to identification of suggested Air Force Specialty Codes (AFSC) for maintenance and operator personnel of the new weapon system (qualitative requirements). The contractor must recommend AFSCs on a task-by-task basis for primary and assisting maintenance or operator personnel. This recommendation is based on a review of the task descriptions contained in AFR 33-1 and AFR 36-1. In almost all cases the contractor recommends an existing AFSC. It should be noted, however, that the contractor is not required to provide the skill level of the AFSC recommended. This is later provided by the procuring agency.

The contractor's recommendations are reviewed by a Human Factors Working Group which is composed of a representative from the SPO and using command. This group makes the final decision concerning AFSCs and skill level requirements. In some situations they may recommend a new AFSC or cross-training of two AFSCs. In general, qualitative manpower requirements are not determined before the full scale development phase of weapon acquisition.

Quantitative Manpower Requirements

There are currently two major data sources which are used singly or in combination for determining the numbers of individuals required for operation and maintenance of a new weapon system. They are: data resulting from a contractor-provided operational/maintenance task analysis, and data resulting from the application of a Logistics Composite Model (LCOM). It should be noted that data from the LCOM may feed into the contractor's task analysis, and vice versa. However, for the sake of clarity, they are discussed separately in the paragraphs below.

Contractor-Provided Operation and Maintenance Task Analysis Data. In acquiring most Air Force weapon systems the Request for Proposal requires bidders to provide estimates of operational and maintenance requirements for the proposed weapon system. After contract award, and during full scale development, the contractor is required to perform a detailed task analysis, providing in-depth data on the operational and maintenance requirements of the weapon system. In some instances these data are obtained from engineering and testing information available to the contractor, and/or from historical data on comparable systems which is available through AFR 66-1. These data may then be used directly to provide quantitative manpower requirements, or will be used as input data for updating the LCOM. Data are collected on a task-by-task basis. Some of the more relevant data collected as a result of the task analysis are:

(a) Identification of the assisting AFSC: The AFSC of maintenance or operator personnel assisting in performing the task.

(b) Contingent Task Interval: Per unit interval between task performances.

(c) Contingent Variable Occurrence: Estimated frequency per sortie of the contingent variable. For example, 25 operating hours/sorties. For each task the estimated frequency is determined for four types of missions (air-to-air combat, air-to-ground combat, peacetime training, and proficiency flying missions.)

(d) Estimated Job Elapsed Time: Estimated time required to perform a primary task and all associated secondary tasks.

(e) Level of Repair: Indication of whether an item is to be repaired at organizational, intermediate, or depot level.

(f) Types of Maintenance Actions: Types of maintenance actions identified are:

   (1) Equipment preparation (on-equipment): Work required to obtain and hook up support equipment, and prepare the aircraft for maintenance (for example, jacking, draining fuel).

   (2) Bench Check (off-equipment): Checkout and fault isolation of equipment in the field shop.

(3) Condemnation (off-equipment): Work necessary to process equipment for condemnation.

(4) Assembly/Disassembly (off-equipment): Teardown, buildup, disassembly, reassembly of equipment removed from the aircraft as a complete unit for checkout and repair in shop.

(5) Repair (off-equipment): Any corrective maintenance action performed off-equipment, including replacement of defective shop replaceable units (SRUS).

(6) Handling, Towing, Washing (on-equipment): Work required in moving aircraft to facilitate operations and maintenance, aircraft washing, and similar organizational maintenance tasks.

(7) Inspect (on-equipment): Preventive maintenance inspection not performed as part of a phased or periodic aircraft inspection.

(8) Launch and Recover (on-equipment): Includes engine start, strapping in pilot, chocking, etc.

(9) Repair in Place (on-equipment): Any corrective maintenance action on-equipment that does not involve replacement of an LRU (line replaceable unit) or repair of an LRU in shop.

(10) Processing of Equipment for Shipment to Another Station: Work required to process and prepare equipment for shipment to another station.

(11) Phase Inspection (on-equipment): Inspection and preventive maintenance performed as part of a periodic or phased aircraft inspection.

(12) Remove/Replace (on-equipment): Removal of an apparently defective LRU, and replacement with an LRU that has been drawn from supply or repaired in shop.

(13) Service (on-equipment): Includes POL, oxygen, nitrogen service.

(14) Troubleshoot (on-equipment): Fault isolation at system or subsystem level to determine the corrective action necessary to clear an apparent malfunction.

(15) Verify (on-equipment): Functional check at system or subsystem level performed after completion of a corrective action to verify that the malfunction has been cleared.

(16) Weapons Load (on-equipment): Work to unload, record, and safe ordinance, and associated mission profile changes.

(g) Maintenance Frequency Type: Indication of whether the task is a preventive or corrective action, and the extent to which it can be scheduled and/or deferred. Each task is coded as follows:

D = Delayed Unscheduled: Used to identify tasks which would normally be postponed until a phased inspection

E = Special Maintenance Scheduled

F = Postflight Inspection

H = Phased Inspection

I = Special Inspection

L = Retirement Life

P = Preflight Inspection

R = Depot Rework

S = Scheduled Replacement

T = Turnaround

U = Unscheduled Maintenance (other than Code D)

(h) Number of Personnel Assisting: The total number of personnel required, whether full or part-time, to aid the primary AFSC in doing a given task.

(i) Number of Men Primary: The total number of personnel required for each task, whether full or part-time, of the primary AFSC needed to do the task.

(j) Primary AFSC: The Air Force Specialty Code of the primary maintenance or operator personnel performing the task.

(k) Quantity per Frequency: Quantity of like items represented by the specific work unit code, task resource data, and task frequency information. This number is used to multiply the reciprocal of contingent task interval in the computation of task frequency.

(l) Removed Item Processing: Applies to Line Replaceable Units (LRU) removed from the aircraft, and Shop Replaceable Units (SRU), removed in field shops. It also includes the percent of removed items that bench check serviceable; the percent of removed items repaired in the field, or at the depot, and the percent of removed items condemned.

(m) SERD Nomenclature: Nomenclature of Support Equipment required to do the tasks.

(n) SERD Quantity: A sequential numbering of all steps (activities) that are required to do the task, including preparation, clean-up, obtaining resources, and positioning equipment, as applicable.

(o) Task Frequency: Rate of task occurrence.

(p) Task Interval: Identification of the most relevant causal variable for use as the basis for specifying maintenance task frequency of corrective maintenance tasks, and the measurement base for scheduled preventive maintenance tasks.

(q) Task/Step Condition: The specification of any abnormal conditions the workers encounter that are not explicit in the task step identification; must accomplish by feel, in total darkness, etc.

(r) Task/Step Criteria: Specification of any unusual constraints/criteria imposed on the maintenance mechanic doing the steps and task; for example, time limitation, error limitation, etc.

(s) Task/Step Criticality: A designation of the criticality of satisfactory completion of the task or step.

(t) Task/Step Identification: A narrative description of the overall task the maintenance mechanic must perform and each step required to do the task. The description must include tools/support equipment required to do each step.

(u) Task Title: Title of task being done.

(v) Tech Order Reference: The number of the applicable AF technical order providing instructions for task performance.

(w) Training Level: A code defining the level of training given to Air Force personnel on the accomplishment of the task.

Obviously, much of the data described above would be useful for determining operator and maintenance personnel requirements for Army weapon system acquisition.

<u>Logistics Composite Model (LCOM).</u> LCOM is another major data source for determining quantitative manpower requirements. As previously noted, it may use data from the contractor-provided operational and maintenance task analysis or it may feed data into that task analysis.

As stated in AFR 25-8, LCOM is a large-scale model that simulates aircraft operation and the main supporting functions that are represented by a mix of sortie types, flight line and shop repair processes for both aircraft and components, and supply functions. The Modeling and Analysis Branch (ASD/ENESA), under the Aeronautical Systems Division Deputy for Engineering, has responsibility for the assembly, analysis, integration, and processing of information for LCOM.

LCOM is a dynamic simulation program, which is used to produce maintenance manpower and support equipment requirements. At the present time it does not deal with operator manpower requirements. It is a "Monte Carlo" model and thus is sensitive to the dynamics of the operational scenario. The output, therefore, may be used to identify peak and minimum requirement periods. Source data for LCOM are available in MIL-STDs-470, 499, 721, and 1388. The detailed scenarios used in LCOM for projecting manpower requirements are fully coordinated with the operating command (TAC, SAC and MAC) and Headquarters USAF. To build the scenario, it is necessary to have the user's operations and maintenance concepts. Contractor data, when available, are consolidated into the source data file. LCOM scenario requirements are shown in Figure 1.

LCOM is used several times during the weapon system acquisition process. Typically its initial use is subsequent to contract award during full scale development. However, for the now defunct Advanced Medium STOL Transport (AMST) program, LCOM was used prior to contractor award. LCOM was also used for demonstration purposes, with substantial modification, to assist in determining maintenance manpower requirements for the Army

1. General Requirements:

   a. Organization level and Unit Equipage (UE) by aircraft type.
   b. Manpower availability (manhours a month).
   c. Indirect work determinant.
   d. Standard manning for Chief of Maintenance overhead and for any work centers that are not simulated.
   e. Manpower Cross Utilization Tasks (CUTs) and Assist Task Qualified (ATQ) assumptions to be used in study development.

2. Facilities and Deployment:

   a. Number of locations and UE size at each site.
   b. Supply concept: for example, deploy with WRSK, resupply engines on Day 10, and full resupply on Day 80.
   c. Resupply time.
   d. Allocation of equipment, such as support equipment, at each site.
   e. Extent of maintenance capability required at each site.
   f. Maintenance concept: for example, remove and replace or remove, repair and and replace
   g. Shelters and facilites at each site.

3. Mission Requirements. Identify mission types. Specify the following mission requirements for each mission type or for each leg of each mission that involves en route stops:

   a. Percent of total sorties.
   b. Aircraft types.
   c. Initial configuration (for example, numbers and types of external tanks, electronic counter-measure pods, cameras, guns, missiles, bombs, cargo handling and passenger conform equipment, etc.)
   d. Probability of and quantity of load expended (for example, tank jettison, air-to-air missile firing, etc.).
   e. Ending configuration and disposition.
   f. Substitution rules for using alternate configurations.
   g. Mission priority.
   h. Flight sizes (maximum, minimum) and policy on sympathetic ground abort.
   i. Sortie rate or mean sortie length and variation.
   j. Recovery and en route point (if not returning to same base).
   k. Probability and conditions of air refueling.
   l. Proportion of sorties or missions flown at night.
   m. Weather limitations by mission type (for example, bomb delivery, air refuel, air engagement, etc.).
   n. Length of delays that can be tolerated before mission cancellation (for example, for weather, maintenance, etc.).
   o. Extent of operation of mission-peculiar equipment (for example, TV monitor if mission calls for AGM 65).

Figure 1. LCOM Scenario Requirements*
*from AFR 25-8, Attachment 1

4. Operations and Scheduling Policy:

   a. Base weather minimums for launch and recovery.
   b. Conditions for air abort (including sympathetic).
   c. Policy for ground or airborne spare aircraft.
   d. Desired percent of available aircraft that will be turned to fly again the same day if possible.
   e. Requirements for complementary missions or mission legs within a restricted time frame.
   f. Requirements for massed launch within a restricted time frame. -

5. Ground Alert:

   a. Number of aircraft or alert per UE deployed location.
   b. Which missions flown from alert as identified in 4C.
   c. Frequency of alert missions, as identified in paragrah 3a.
   d. Replacement policy (for example, replacement when lauched or same aircraft return to alert).
   e. Duration of alert cycle.
   f. Disposition at end of alert cycle.
   g. Aircraft acceptance of alert quick turn policy and procedures.
   h. Policy for dedicating personnel and equipment to alert.

6. Functional Check Flight (FCF):

   a. Conditions requiring FCF.
   b. Limitations of FCF (for example, daylight only).
   c. FCF duration and probable range of variation.

7. Maintenance Concepts and Organization:

   a. Organization structure (for example, per AFM 66-1).
   b. AFSC structure (for example, integrated avionics versus functional avionics specialties).
   c. Quick turn conditions and procedures, including criteria for deferred maintenance.
   e. Policy for launch support.
   f. Conditions requiring down load.
   g. Repair level concept by subsystem.

8. Combat Damage:

   a. Identify the threat to be used in estimating attrition and battle damage.
   b. Extent of Reliability, Affordability, Maintainability (RAM) team or reserve augmentation for combat damage repair.
   c. Policy for allocating combat damage repair to base, team, or depot.

Figure 1. LCOM Scenario Requirements (continued)

9. Other Study Assumptions:

a. Identify by mission types:

(1) The time before scheduled take-off that briefing should begin.
(2) The time after landing when debriefing is scheduled to be completed.
(3) Any reduction in briefing or debriefing time when missions are flown in succession.

b. Describe aircrew scheduling rules:

(1) Formed crews.
(2) Multiple seat qualification.
(3) Flight lead or special qualification.
(4) Squadron integrity.
(5) Additional duty requirements (identify duties that must be scheduled and completed on a daily basis such as supervisor of flying and mobile control (average hours per duty day for each crew member).
(6) Maximum flight duty period.
(7) Minimum crew rest periods.
(8) Days off policy.

Figure 1. LCOM Scenario Requirements (continued)

M-1 Tank. In addition, the Air Force Test and Evaluation Center (AFTEC) frequently uses LCOM data in their evaluation of new weapon systems (e.g., A-9 and A-10 aircraft programs).

LCOM is a powerful model for determining maintenance manpower requirements within major aircraft weapon systems. It would be difficult to apply LCOM to weapon systems acquired by other Air Force product divisions because it is greatly oriented to aircraft systems; also, source data for major aircraft are more likely to be available than for other weapon systems. The application of LCOM to an Army weapon system, or to any acquistion other than an aircraft system, requires considerable modification of the model (e.g., development of new scenarios). Application to the M1 tank, for example, was more dfficult than would be practical to repeat for other applications (the missions, scenarios, and variables had to be changed, etc.).

ACQUISITION OF SUPPORTABLE SYSTEMS EVALUATION TECHNOLOGY (ASSET)

The data provided by LCOM and especially the contractor task analysis are usually made available during the full scale development phase of weapon systems development. The Air Force recognizes the need for obtaining these data at an earlier weapon system development phase, and the need for using several human resource technologies in the weapon system acquisition process.

ASSET is a systematic, proceduralized methodology that can be used to:

- o Provide assessments of cost, human resources, and logistics resources that are required for support and operation of weapon systems.
- o Coordinate the development of training programs and technical manuals.

- o Ensure that supportability considerations and human resource impacts are explicitly considered in the design of the weapon system.

ASSET can be employed during early conceptual phases through production and deployment of the weapon system.

As described in the ASSET User's Guide, the three basic elements of ASSET are a consolidated data base, eight analysis procedures, and eight analytical computer models (Figure 2). A brief description of the basic elements has been extracted from the User's Guide (Liberati, 1982) and are as follows:

Consolidated Data Base

ASSET is supported by a Consolidated Data Base (CDB) which is prepared for the weapon system under consideration. The data base contains, at a single location, all information required to analyze the human resource and support impacts during the weapon system acquisition process. It is initially developed from historical and comparative data available through AFR 66-1. It can then be updated with current acquisition information as it becomes available. As the system acquisition proceeds from design through development, the CDB is improved in accuracy and detail by replacing planning and historical information with information acquired on the actual system.

Procedures

There are eight procedures as described below:

- o Program Definition Analysis Procedure. Program requirements, including a key event and operational readiness schedule, and a detailed phased schedule are identified. The support plans, a series of basic statements describing the Integrated Logistics

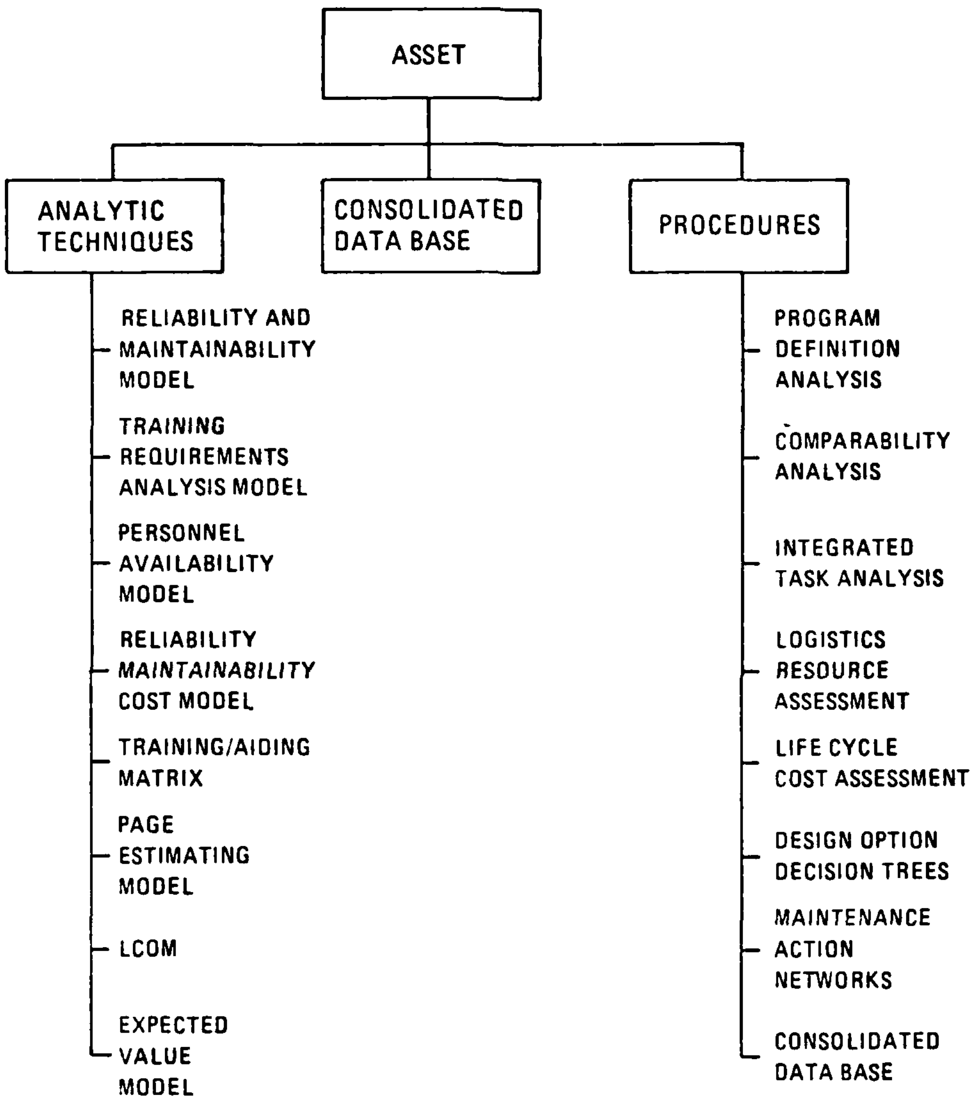


Figure 2. **Elements of ASSET Methodology***

*From Westinghouse Electric Corp, 1982, p I-1-3.

Support (ILS) elements and reflecting the latest ILS decisions, are also identified. In summary, the program definition analysis procedure identifies the applicable weapon system design and support requirements.

- Consolidated Data Base Procedure. The establishment of the Consolidated Data Base has been described above.
- Integrated Task Analysis Procedure. The Integrated Task Analysis Procedure in ASSET outlines a systematic study of the tasks which must be performed to operate and maintain a weapon system. Results of the task analysis help in the determination of training objectives and of the behaviors and tasks a technical manual must support.
- Maintenance Action Network Procedure. The Maintenance Action Network Procedure depicts the maintenance flow of a system and defines the input data used in the application of ASSET as an assessment methodology. With the exception of subsystem failure, each event in the Maintenance Action Network is annotated to indicate the probability that the event will occur, the time to complete the event, the maintenance personnel characteristics (skills, level, and quantity) to support the event, and the support equipment (type and quantity) required to support the event. Subsystem failure is annotated only with the probability of occurrence.
- Logistic Resources Assessment Procedure. This procedure is used to identify, evaluate and challenge the logistic resources requirements posed by a weapon system. Logistic resources include

such items as manpower, skills, tools, support equipment, spares, facilities, training and technical manuals, and impact on the total support of the weapon system.

- <u>Comparability Analysis Procedure</u>. This procedure is the overall process in ASSET used to develop data on newly proposed or designed weapon systems by (a) selecting operational equipment similar to that of the proposed weapon system and (b) adjusting the resource data associated with operational equipment to reflect the unique characteristics of the proposed equipment.
- <u>Life Cycle Cost Assessment Procedure</u>. This procedure provides the user with several tools for life cycle cost analysis.
- <u>Design Option Decision Tree Procedure</u>. The design option decision tree (DODT) provides a means of accounting for the many trade-offs that are performed during the course of a system design effort and identifying the critical decision points during design. Some factors which influence the decision options are the performance requirements of the system, logistics, weight, cost, reliability, and development risk. Human resources data related to personnel, training, and maintenance impacts can be added as a system requirement. As design options, these data can include quantity of personnel required to perform maintenance troubleshooting on the equipment, job specialty of the maintenance personnel, time to troubleshoot a failure in the equipment, ease of maintaining the equipment, and complexity of tools required to perform maintenance work on the equipment.

Analytic Techniques

There are eight computerized models which support the ASSET decision-making processes. These models are described below:

- Reliability and Maintainability (RM) Model. The RM Model focuses on calculating estimates of mean-time-to-repair (MTTR), maintenance manhours, and system and subsystem availability based on the underlying system and support concept. The model considers maintenance functions such as adjust, align, calibrate, trouble-shoot, inspect, operate, remove/install, repair, service, etc. Three measures are calculated by the model. These are (a) meantime to repair ((MTTR) per 1000 flight hours, (b) maintenance manhours (MMH) per 1000 flight hours, and (c) flightline system availability. The RM model is an average value model and is therefore most appropriate for use in initial studies and trade-off analyses in the conceptual acquisition phase.
- Reliability, Maintainability, and Cost Model (RMCM). The RMCM estimates life cycle costs of weapon systems. The interactive RMCM program performs four major functions: R&M computation, cost computation, R&M perturbation, and cost perturbation.
- Training/Aiding Matrix (TAM) Model. TAM presents an assessment of training and technical manual information relevant to the acquisition of a weapon system or subsystem. TAM provides information on content requirements in terms of the degree of coverage required in training and/or technical manuals for flightline, troubleshooting and non-troubleshooting, plus shop repair tasks.

- Page Estimating (PAGES) Model. PAGES is used to determine the quantity and types of pages that will be required for both flight-line and shop technical manuals. Inputs to the model are type of system and number of composite subsystems, line replaceable units and shop replaceable units. Output results are estimates of the total page requirements and are qualified as troubleshooting or non-trouble-shooting. The types of pages that can be identified are narrative, half-tone art, half-tone explosion, electronic line art, exploded line art, fault isolation chart, fault isolation schematic block, access line art, fault isolation schematic flow, fault isolation schematic mechanical and hydraulic, job guide narrative, and job guide illustrations.
- Training Requirements Model (TRAMOD). TRAMOD can facilitate the rapid estimation of training requirements and the consequences of alternative approaches to fulfilling them. The model aids weapon system designers and planners in considering the training implications of design. TRAMOD requires input data relating to the task to be performed, with each task assigned a user-defined value for each of five characteristics denoting frequency, criticality, learning difficulty, and psychomotor and cognitive levels. The model provides potential training plans and scenarios.
- Personnel Availability Model (PAM). The PAM is a predictive model that estimates the numbers of personnel in 12 selected maintenance AFSCs at user-specified future dates. These AFSCs are defined internally in the program and cannot be altered by the user.

- Logistics Composite Model (LCOM). This dynamic simulation model which is used to assess maintenance manpower and support equipment requirements has been previously described. LCOM is an important model within ASSET.
- Expected Value Model (EXPVAL). The EXPVAL model is an average value model usually exercised in conjunction with the LCOM simulation model to assess logistic resources such as maintenance manpower and support equipment requirements. EXPVAL output yields the "expected" total maintenance time for each AFSC and use time for each item of support equipment per task.

SUMMARY

The ASSET methodology is currently undergoing evaluation. A seminar was given to potential users in late September 1982 by personnel from the Air Force Human Resources Laboratory, Wright-Patterson Air Force Base.

Review of ASSET indicated that it should prove to be a very useful methodology when applied to acquisition of aeronautical weapon systems. It would probably be of lesser value for use with non-aeronautical weapon systems because of extensive scenario revision required, such as that for the M1 tank. While many of the models with ASSET seem to have value for Army use they require considerable adaptation and therefore are not practical for ARMPREP.

REFERENCES

Air Force Regulation 33-1, United States Air Force Recruiter Helper Program, November 28, 1980.

Air Force Regulation 36-1, Officer Classification Regulation, March 1, 1977.

Air Force Regulation 66-1, Maintenance Management (5 volumes), August 15, 1979 - January 2, 1980.

Department of the Air Force Regulation 25-8, Management engineering: Logistics composite model (LCOM), November 3, 1978.

Department of Defense Military Standard 499A, Engineering Management, May 1, 1974

Department of Defense Military Standard 721C, Definition of Terms for Reliability and Maintainability, June 12, 1981.

Department of Defense Military Standard 470, Maintainability Program for Requirements for Systems and Equipment, March 21, 1966.

Department of Defense Military Standard 1388/1 [N-3], Logistics Support Analysis, October 15, 1973.

Department of Defense Military Standard 1388/2 [N-2], Logistics Support Analysis Data Element Definition, October 15, 1973.

Liberati, G. L., Test and evaluation of technology for acquiring supportable systems; user's guide (Draft). Hunt Valley, MD: Westinghouse Electric Corporation, May 1982.

APPENDIX C

LIST OF FIELD TRIPS

LIST OF FIELD TRIPS

JUNE

15 US Navy HARDMAN Office. Briefed on HARDMAN methodology as applied by the Navy. Interviewed Lt Cdr Luengen.

JULY

14 Soldier Support Center, National Capital Region (SSC-NCR) at Alexandria, Virginia. Briefing on SSC-NCR responsibilities and CODAP.

AUGUST

4-6 Materiel Readiness Support Agency (MRSA) at Bluegrass Army Depot Lexington, Kentucky. Responsible for:

- Reviewing BOIP feeder data (BOIPFD) received from the Equipment Authorization Review Activity (EARA).
- Reviewing QQPRI received from the New Equipment Training (NET) team of the Materiel Readiness Commands (MRC).
- Proponent for the DARCOM maintenance manpower authorizations criteria (MACRIT) file. This file is the primary tool used by NET team members to develop the Direct Productive Annual Maintenance Manhours (DPAMMH) required at each echelon of maintenance for the development item.
- Assembling the BOIPFD and QQPRI and forwarding them to HQ TRADOC.
- Maintaining two automated MIS related to materiel development:
  - Integrated Logistic Support Milestone Reporting System (ILSMRS)
  - Force Modernization Milestone Reporting System (FMMRS)

13 Air Force Systems Command, Aeronautical Systems Division, Modeling and Analysis Branch. Discussed LCOM and points of contact in the A.F.

AUGUST

16-20 Communications - Electronics Command (CECOM) at Fort Monmouth, New Jersey, Interviewed:

- Logistics specialists who prepare the BOIPFD for communications equipment.

- NET analysts who prepare the QQPRI for communications (ground and avionics) and electronic intelligence gathering/processing equipment.

18-20 Wright-Patterson AFB, Human Research Lab. Discussed ASSET.

22-23 HQ TRADOC at Fort Monroe, Virginia. Interviewed:

- Combat developers who:

  - Maintain the automated BOIP system.

  - Distribute the BOIP to the proponent school for coordination and integration of recommended input.

- Training developers who review the proponent school submission for validity of the MOS recommendations.

24 US Navy HARDMAN Office. Discussed operational limitations and field experience with HARDMAN methods. Interviewed Lt Cdr Luengen.

24-27 Missile Command (MICOM) and the Missile Maintenance Center and School, at Redstone Army Arsenal in Huntsville, Alabama. Interviewed:

- Materiel system coordinators who prepare the BOIPFD.

- Analysts who acquire the materiel line item number (LIN) and standard study number (SSN) for each developmental item.

- Net analysts who prepare the QQPPRI.

- Combat developers who assess the doctrinal impact of the modernization system.

- Training developers who assess the BOIP for training impact, to include the Soldiers Manuals.

SEPTEMBER

9 Logistics Center and Quartermaster Center and School at Fort Lee, Virginia. Interviewed:

- Proponents for the TRADOC MACRIT file. This file is intended for use by TOE developers because it contains the AMMH (i.e., the DPAMMH increased by the nonavailability of maintenance performers). In actuality, many NET analysts use this MACRIT file (vice the MRSA version) because it is considered to be more current.

- Coordinator of the BOIP for the QM School who evaluates and integrates combat and training developers input.

23 Ordnance Center and School at Aberdeen Proving Ground, Maryland. Interviewed:

- Reviewer of all BOIPFD and BOIP which affect maintenance unit TOEs. Prepares BOIP for all maintenance TOE-related modernization equipment.

- Reviewer of all QQPRI and BOIP which affect maintenance MOSs.

- Maintenance MOS proponent for policy and doctrinal implications.

OCTOBER

6 SSC-NCR, MOS Structure Division. Responsible for AR 611-201 and final MOS recommendation. Reviewed ARMPREP taxonomies.

NOVEMBER

1 SSC-NCR, MOS Structure Division. Responsible for AR 611-201 and final MOS recommendation. Reviewed ARMPREP taxonomies. Reviewed revised MOS structure and Task Structure Taxonomies.

APPENDIX D

EXPLANATION OF TERMS

Army Acquisition Objective (AAO)	The quantity of an item of equipment or ammunition needed to equip the approved US Army Force and sustain that force, together with specified allies. This applies in wartime from D-Day through the period prescribed and at the support level directed in the latest OSD Consolidated Guidance.
Associated Support Items of Equipment (ASIOE)	Items of equipment needed to operate and maintain the BOIP item. They are authorized separately in TOE and TAADS documents.
Automated Unit Reference Sheet (AURS)	A document which, generally, proposes or portrays certain basic data for organizational development. It provides information for use in developing BOIP and Draft Plan TOE to support concepts and doctrine studies and computer assisted war game simulations.
Availability Date	Estimated date on which the production items can be available for initial issue to an organization after type classification Standard LCC A.
Basis of Issue Plan (BOIP)	A planning document that lists certain TOE, TDA, CTA, JTA, and AOP in which a new item will be placed; the number of items to be included in each organization element; and other equipment and personnel changes needed because of the new item. BOIP is not an authorization document.
Catalog of Approved Requirement Documents (CARDS)	A DA catalog of approved requirements which provides current information to combat developers and the research and development communities.

Combat Developer	The command or agency responsible for doctrine, concepts, requirements, and organizations. This includes systems for retail level logistics support, primarily for Army forces in a theater of operations.
Combat Development Item	A new item of equipment developed or procured in response to a DA approved materiel requirement document. It is intended mainly to be used in a theater of operations or to control civil disturbances.
Component Items	Major end items of equipment identified, authorized, cataloged, and issued as part of the BOIP item configuration.
Materiel Developer	The command or agency responsible for research, development, and production validation of a system (including the system for its wholesale level logistics support) which responds to HQDA approved materiel requirements.
Nondevelopmental Items	Items available for procurement with no expenditure of Army Research, Development and Evaluation (RDTE) funds. These items are: a. Items commercially available. b. Items developed and accepted by other military Services. (This includes cryptologic items developed by the National Security Agency.) c. Items of other governmental agencies or countries.
Principal Item	The item for which the BOIP is developed.
Qualitative and Quantitative Personnel Requirements Information (QQPRI)	Organizational, doctrinal, training and personnel data developed by the materiel developer, in coordination with TRADOC, for new or modified materiel items.

Requirements Documents	a. Materiel requirements documents. Documents which require preparation of and are supported by a BOIP unless exempted by AR 21-2. Examples are: Required Operational Capabilities (ROC), Letter Requirements (LR), Training Device Requirements (TDR), Training Device Letter Requirements (TDLR), and Letters of Agreement (LOA). b. Tables of Organization and Equipment (TOE). A table which prescribes the normal mission, organizational structure, and personnel and equipment requirements for a military unit. It is the basis for an authorization document.
Structure and Composition System (SACS)	A system which relates Force Accounting System (FAS), The Army Authorization Documents System (TAADS), Basis of Issue Plan (BOIP) System, and Table of Organizational Equipment (TOE) System data bases into one computation.
Standard Study Number (SSN)	An 11-position alpha numeric code assigned by an MRC. It indicates either a single LIN or Department of Defense Ammunition Code (DODAC) or group of LIN or DODAC that require computations on Army Materiel Plan (AMP) and Total Army Equipment Distribution Program (TAEDP).
Training Device	Items which simulate or demonstrate the function of equipment or systems such as three dimensional models, mockups, or exhibits. They are designed, developed, or procured solely for training support.
Type Classification or Reclassification	Items of Army materiel entering the inventory or items procured to fulfill operational needs normally required to be type classified before procurement.

Z Line Item Number (LIN)	A temporary number assigned by DARCOM, for planning purposes, to a developmental or nondevelopmental item before the TC Standard (LCC A) (AR 708-1).

APPENDIX E

MANPOWER AUTHORIZATION CRITERIA (MACRIT)

Contents

MANPOWER AUTHORIZATION CRITERIA (MACRIT)

INTRODUCTION

The field interviews and QQPRI symposia notes indicate that generating reasonably accurate Direct Productive Annual Maintenance Man-Hours (DPAMMH) for the developmental system is the most difficult part of QQPRI preparation. In fact, the LOGCEN recently sponsored a study by Northrop Corporation to recommend improvements to the MACRIT system. It is the NET analyst who must develop the DPAMMH and put them into the QQPRI. At this point in the LCSMM, the ILS, LSA, and LSAR should include maintenance information. However, information may be in the hands of a contractor and the NET analyst must dig to obtain the maintenance information required for the initial QQPRI submission.

MACRIT COMPLICATIONS

Why should the development of DPAMMH be perceived as such a difficult task? Some of the performance-inhibiting factors are:

a. The NET analyst is primarily a training specialist, while the task of developing DPAMMH is more appropriate for the preparer of the BOIPFD--the logistics analyst.

b. There is no formal program to train the NET analyst in developing DPAMMH and preparation of QQPRI. Most NET Analysts interviewed were former military repairmen or instructors, which partially offset the lack of formal training. Interviewees without the military experience fel they were at a disadvantage.

c. Regardless of background, no single publication clearly explains the MACRIT system. To write this appendix required analysis of these official sources which only contribute pieces to the MACRIT puzzle.

- AR 71-2, BOIP and QQPRI
- AR 570-2, MACRIT
- DARCOM Supplement 1 to AR 570-2, MACRIT

- DARCOM Pamphlet 750-16, guide to logistic support analysis
- 1982 QQPRI Symposium notes and vugraphs
- Computer printouts, MRSA data base
- Interview with MRSA MACRIT representatives
- Computer printouts, LOGCEN data base
- Interviews with LOGCEN MACRIT representatives

d. Some examples of confusion within the publications are:

- The BOIP-QQPRI regulation (AR 71-2) requires the submission of DPAMMH but cites no MACRIT data source (e.g., DARCOM Supplement to AR 570-2).
- AR 570-2 uses the term Direct Productive Time (DPT) instead of DPAMMH. However, DPT is not listed in the index and is defined within the paragraph entitled "indirect productive time."
- DARCOM Supplement to AR 570-2 states (page 6, paragraph 2-6)..."Further, DPAMMH data should be arrived at using the LSA/LSAR system."
  - Our interviews indicated LSA (if performed at all) is usually performed during Full-Scale Engineering Development and the results are published near Milestone III (too late for initial QQPRI development).
  - The TQQPRI are scheduled for submission to TRADOC through MRSA 9 months before the completion of Milestone II (reference AR 71-2).
- There are three sources of MACRIT data; and with different file maintenance schedules, the contents tend to differ. The MACRIT sources are:
  - AR 570-2 (once published, represents a static reference)
  - MRSA MACRIT File (the source of AR 570-2; but after publication, this automated file continues to be updated with changes)
  - LOGCEN MACRIT File

ACCURATE ESTIMATES OF MAINTENANCE WORKLOAD

The differences in the MACRIT files and the confusing guidance in AR 71-2 combine to inhibit accurate estimates of the maintenance workload. For example:

- A major limitation to the DARCOM MACRIT file is that it only contains equipment which is separately authorized, i.e., has a LIN. This is a logical constraint for the TRADOC file because it is used to develop TOE and unit authorizations (which require LIN). It is not logical for the DARCOM file because they manage items at the National Stock Number (NSN) level of detail. There are many maintenance-significant items of equipment which are "hidden" in sets and assemblages, and it is difficult to acquire their DPAMMH. Examples are: (1) two-and- one-half and five-ton truck chassis which are components of shop sets, (2) trailers used with AC generators to form mobile power units, and (3) storage tanks and water pumps which form water purification sets. To acquire the component item DPAMMH, the NET analyst must (somehow) know to use a comparable item DPAMMH or query the MRC which is proponent for the component. MRSA (proponent for the DARCOM MACRIT file) could maintain an NSN level file and use the NSN-LIN cross-reference file to build a LIN file for LOGCEN and AR 570-2.
- The AR 570-2 data are published biannually from the MRSA data base; however, an indirect productive factor (to be explained) is added so that each DPAMMH is increased by 40%.
- The LOGCEN MACRIT file also contains factored man hours data.

MULTIPLE MACRIT SOURCES

A graphic representation of the multiple sources required to obtain DPAMMH is shown in Table E.1. At the top of the table are the three general categories of equipment comprising the developmental

TABLE E.1

POTENTIAL SOURCES OF DPAMMH FOR ITEMS OF EQUIPMENT WITHIN THE NEW SYSTEM

SOURCE	DEVELOPMENTAL SYSTEM				
	Developmental Item	Components		ASIOE	
		Not TC	TC	Not TC	TC
Engineering estimates	X	X		X [1]	
DT/OT results	X	X	X		X
Supporting MRCs		X			
MACRIT - MRSA [data base]					
(comparable item) [2]	X	X	X	X	X
(preferred item) [3]			X		X
NOTE - FILES BELOW CONTAIN ONLY AMMH; DPAMMH ARRIVED AT INDIRECTLY [4]					
MACRIT - AR 570-2 [hardcopy]					
(comparable item)	X	X	X	X	X
(preferred item)			X		X
MACRIT - LOGCEN [data base]					
(comparable item)	X	X	X	X	X
(preferred item)			X		X

1. When ASIOE are also under development
2. When using DPAMMH of comparable item instead of engineer estimate
3. When using DPAMMH of the preferred item (with LIN) from MACRIT
4. The AMMH should be divided by 1.4 (assuming non-depot units, else divide by 1.22) to develop the DPAMMH

system. The other alternatives are whether or not an item is type-classified (TC). Along the left margin are the possible sources of DPAMMH. An explanation follows:

a. Developmental item (to include ASIOE under development)

- The best estimate of DPAMMH would be provided by the developing engineer, especially when LSA data are available. When unavailable, comparable item MACRIT data are used.
- The results of developmental and operational tests (DT/OT) should be evaluated to determine if the earlier DPAMMH estimates should be updated. The M1 tank's AMMH are still M60-series duplicates according to LOGCEN representatives.
- An early estimate could be acquired by using the DPAMMH of a comparable item (e.g., the M1 tank PM used the DPAMMH of the M60).

b. Components (not TC)

- The engineering estimate can come from the system developer or the manufacturer of the component.
- The DT/OT results may provide a good estimate of the DPAMMH, especially since they would represent a developmental item and component interaction.
- The proponent MRC <u>may</u> have the DPAMMH in hardcopy.
- An alternative would be the substitution of a comparable (TC) item from the MACRIT files (e.g., using a five-ton cargo truck for the five-ton truck chassis.)

c. Components and ASIOE (TC)

- DT/OT results may provide an accurate estimate of the DPAMMH in that specific application.
- The preferred estimate would be in the MACRIT files and copied directly into QQPRI.
- If the DPAMMH are missing or suspect, a comparable item can be used.

ESTIMATING ANNUAL WORKLOAD

Table E.2 is intended to present on a single chart all of the terms relevant to the process of calculating the number of repairmen required for an estimated annual workload. The partitioning of the chart into three sections is intended to cluster the terms under the appropriate concept. For example:

a. Time Required to Repair - The workload represented by one or more items of equipment. The related terms are:
   - Direct (wrench-turning) time
   - Indirect (mostly travel to job site) time
   - AMMH are the measures of annual work represented by each item of equipment with a LIN

b. Time Available to Repair - The number of annual man hours each repairman is expected to be available under sustained operating conditions (e.g., wartime).
   - This formula understates the military repairmen requirements during peacetime (i.e., 40-hour week).
   - The terms are self-explanatory except perhaps the unit movement term, which refers to the tactical displacement of the supporting unit.

c. Number of Repairers Required - In this formula, the annual organizational maintenance workload is divided by the annual available man hours of one repairman to develop the total number of required repairmen.

POTENTIAL FOR UNDERSTATING WORKLOAD

A peculiar requirement in AR 71-2 may be causing the maintenance man hours to be understated in the MRSA MACRIT files. In preparing the OQPRI, the NET analyst is required to list all items of equipment in the system but not provide DPAMMH for type-classified items. (Though this isthe result of a TRADOC initiative, it is now subject to change based on revised recommendations being formulated at SSC-NCR.) The result would be as depicted in the following example.

TABLE E.2

TIME REQUIRED TO REPAIR

- DPAMMH - Direct Productive Annual Maintenance Man Hours: the estimated wrench-turning time required to repair a component or assembly.

$$\text{DPAMMH} = \frac{\text{Equipment Usage Rate}}{\text{Mean Time Between Repair}} \times \text{Mean Time To Repair}$$

- IPAMMH - Indirect Productive Annual Maintenance Man Hours: the estimated time related to job performance but not in the "hands-on" mode. Examples are: parts chasing, tool cleaning, and travel to and from the maintenance job.

IPAMMH = + 40% at Organizational level
+ 40% at DS/GS level
+ 22% at Depot level.

- AMMH - Annual Maintenance Man Hours: the sum of the direct and indirect productive times (required to repair an item).

AMMH = DPAMMH + IPAMMH

TIME AVAILABLE TO REPAIR

- TTA - Total Time Available: Man Day (single shift) 12 hours
Man Year (365 days) x 365
4380 hours

------ minus these hours --------------

	%	hours	
NPT - Nonproductive Time			
Security	5.33	234	
Kitchen police	2.00	88	
Work details	3.33	146	
Messing	6.24	273	
Casualties/R&R	3.00	130	
Personal needs	4.10	180	
	24.00	1051	-1051 hours
% of time unit on the move			
Category I TOE	25.00	830	- 830 hours
II TOE	19.00	630	+
III TOE	7.00	230	

- AAMMH - Annual Available Maintenance Man Hours
[e.g., Category I TOE (rounded)] 2500 hours

NUMBER OF REPAIRERS REQUIRED

- Repairers required $= \frac{\text{equip density} \times \text{AMMH}}{\text{AAMMH}}$

EXAMPLE

(An Air Defense Fire Control Center (FCC) installed in a large van; i.e., an S-280 shelter mounted on a flatbed trailer)

Developmental Item	TC	Who Provides: DARCOM/ DPAMMH	Who Provides: TRADOC/ AMMH
FCC	(NA)		
Components			
Shelter S-280	No	5	7
Entrance, CBR	No	2	3
Radios (3)	Yes		171
Air Conditioners (2)	Yes		448
12-Ton Semi-Trailer	Yes		400
		+	+
DPAMMH		7	
AMMH			1,029

Probable man-hours for FCC LIN in MACRIT Files:

MRSA (no TRADOC feedback)	7 DPAMMH
LOGCEN (summed)	1,029 AMMH

In the example, the NET analysts would only provide the DPAMMH for those components not type-classified. At this point, the FCC in the DARCOM MACRIT file would only reflect a 7-hour DPAMMH.

At TRADOC, the Ordnance School analyst would: (1) convert the DPAMMH to AMMH, and (2) use the LOGCEN MACRIT file to obtain the AMMH for the type-classified components. When the LOGCEN MACRIT file is updated, the FCC would reflect a 1,029-hour AMMH.

A few subtleties occur at this point:

- The TRADOC analyst is developing a BOIP, not updating the information provided by the QQPRI (which still reflects a 7-hour DPAMMH). The difference between DARCOM (DPAMMH) and

TRADOC (AMMH) is required to develop a proper organizational QQPRI.

- The calculation of AMMH is an intermediate step towards determining the number of repairman positions. Therefore, the AMMH will not be inserted into the BOIP either, and the manpower staffing basis is not available for subsequent review processes.
- The only way the MRSA MACRIT file could reflect the appropriate (i.e., 735) DPAMMH for the FCC LIN would be:
  - For a DARCOM analyst to replicate the TRADOC analyst's actions.
  - Communicate with the TRADOC analyst.
  - Await publication of the LOGCEN MACRIT file and convert the AMMH to DPAMMH.

SUMMARY

Table E.3 depicts a graphic summary of the information discussed in this appendix. The intent is to convey the cognitive complexity faced by the participants in the BOIP process.

Note the difference in maintenance man hours among the files:

- QQPRI only contains DPAMMH for non-type-classified items.
- The MRSA DPAMMH for the FCC would be the sum of these calculations:

Quantity	Item	Item DPAMMH		Total DPAMMH	Mechanic
3	Radio	41	=	123	Radio
2	Air Conditioner	160	=	320	Refrig.
1	Shelter	5	=	5	
1	Entrance	2	=	2	
1	Semi-Trailer	286	=	286	
				293	Wheel Veh.

TABLE E.3

MOST BOIP PROCESS PARTICIPANTS HAVE NOT MASTERED THE RELATIONSHIP AMONG THESE FOUR FILES: BOIPFD - QQPRI - MACRIT (MRSA) - MACRIT (LOGCEN)

Example: An air defense fire control center (FCC) installed in a large van (e.g., an S-280 shelter mounted on a flatbed trailer), pulled by a 5 ton tractor, and electrified by a 25 KW trailer mounted power unit.

EQUIPMENT CATEGORY Item name	LIN	ORG LEVEL QQPRI DPAMMH	 MRSA DPAMMH	 LOGCEN AMMH	 Mechanic
<=========== BOIPFD	===========>				
<=========== QQPRI	==========	==========>			<========>
<=========== MACRIT	==========	==========	==========	==========	==========>
DEVELOPMENTAL ITEM					
Fire Control Center	Z12345	—[1]	123	172	radio
			320	448	refrig
			293	410	wheel veh
COMPONENTS OF FCC					
1 shelter S-280	NA	5	ITEMS WITHOUT LIN		wheel veh
1 entrance CBR	NA	2	ARE NOT IN MACRIT		wheel veh
3 radios AN/VRC-12	R23456	—	41	57	radio
2 air conditioners	A34567	—	160	224	refrig
1 12 ton semi-tlr	S45678	—	286	400	wheel veh
ASIOE					
Power Unit (PU)	P56789	—		622	pwr gen
				128	wheel veh
Truck, tractor, 5 ton	T89012	—	254	356	wheel veh
NOT LISTED IN QQPRI			BUT LISTED IN MACRIT FILES		
COMPONENTS OF PU					
2 12.5 KW generators	G67890		222	311	pwr gen
1 2.5 ton trailer	T78901		91	128	wheel veh

1. Not entered because it's entirely composed of separate components

- The LOGCEN file AMMH are the product of multiplying DPAMMH by 1.4.
- All TC component items will be in MACRIT files as independent items under their own LIN and summed under the developmental LIN.
- ASIOE are not summed under the developmental LIN.

APPENDIX F

REVIEW OF BEHAVIORAL TAXONOMIES

CONTENTS

APPENDIX F
REVIEW OF BEHAVIORAL TAXONOMIES

CONTENTS (Continued)

REVIEW OF BEHAVIORAL TAXONOMIES

INTRODUCTION

Definitions and characteristics of taxonomies, particularly those in the behavioral sciences, are needed to clarify the application of taxonomic techniques to ARMPREP. These definitions are described in this section, followed by procedures for developing taxonomies, methodological approaches, uses, and constraints of taxonomies. The section ends with a discussion of general criteria for evaluating taxonomies.

The next section presents requirements for the development of an Army MOS-related taxonomy, including specific criteria and identification of existing taxonomies. The third section identifies taxonomic approaches in the behavioral sciences and the following one presents a detailed discussion of how well specific behavioral taxonomies apply to ARMPREP requirements. The final section summarizes the conclusions. In general, Army personnel documentation meets ARMPREP needs better than behavioral taxonomies in the psychological and behavioral literature.

NATURE OF TAXONOMIC SYSTEMS

Definitions and Characteristics of Taxonomies

Definitions of taxonomies emphasize their classification of content and their uses. Some definitions in the literature are:

1. A taxonomy is a "set of theoretical principles, procedures, and rules that serve as the basis for classification" (Ramsey-Klee, 1979, p. 6)

2. A taxonomy is a means of classifying objects or phenomena in a way that establishes useful relationships (Miller, 1967)

3. "A taxonomy involves the systematic differentiation, ordering, relating, and naming of the groups within a subject field" (Silverman, 1967, p.2)

4. A "taxonomy is a prerequisite for classification...the organization of tasks, or of any subject matter, into groups requires the previous development of a sound logic and rationale for the organization" (Theologus, 1969, p.25)

5. "A taxonomy must be so constructed that the order of the terms must correspond to some "real" order among the phenomena represented in the terms" (Bloom, 1956, p. 17)

In the biological sciences, for example, taxonomies order plants and animals according to their underlying dimensions. This stratification (i.e., family, genus, species) is based on the subordination of elements into an unambiguous system in which each element has an exact location. It assumes an ordered and static relationship of subgroups in a hierarchy. The hierarchy serves as an organizing scheme for a user community. The hierarchical nature of the taxonomy enhances understanding of location of taxonomic elements in relation to other elements.

Taxonomies consist of the class names, definitions of the relationships among the classes, and the instructions for use. A taxonomy highlights essential properties of the phenomena and their relationships. Applied to ARMPREP, the taxonomy must organize and clarify information used in estimation of manpower and personnel requirements for the Army.

Development and Refinement of Taxonomies

A major task in creating a taxonomic system entails selecting appropriate symbols, defining them, and securing consensus regarding their meaning in the user community. This task is a prerequisite for assigning elements to the taxonomic categories, and the assignment process is predicated upon detecting similarities and differences between taxonomic elements.

In analysis of variance terms, the taxonomy minimizes within-cell (cluster) variance and maximizes between-cell variance. Sneath (1957) estimates the degree of similarity between objects as follows:

$$S = N_s / N_f$$

Where:

S = Similarity

N_s = number of positive features possessed by both objects

$N_f = N_s + N_d$

N_d = number of features possessed by first, but not second object, and number of features possessed by second, but not first object.

Sneath concludes that overall similarity is the basic concept of an ideal classification system. Sneath, however, worked in microbiology, and quantifying similarity in a behavioral taxonomy may not be as simple. Some classification function which measures the similarity among elements is required for the taxonomy. According to Mathis (1970), this similarity function allows the development of a classification procedure. He asserts that the following conditions are necessary for taxonomic procedures:

1. The classification must be well-defined: application of the algorithm must supply a single result

2. The classification must be stable: the classification must not be grossly affected by small changes in the data

3. The classification must be independent of the labeling of the objects: the classification must be unaffected by a permutation of the names of the objects

4. The classification must be independent of scale: the classification must be unaffected by multiplication of the similarity function by a positive non-zero constant

Taxonomic development requires configurations of variables, relationships, and behavioral phenomena in a coherent, logical, and useful fashion. Class boundaries must be determined for the inclusion or exclusion of specific elements. Silverman (1967) recommends the following developmental steps:

1. Collect samples of phenomena in the realm of interest
2. Describe essential features of the elements
3. Compare the phenomena for similarities and differences
4. Develop a set of principles governing the choice and relative importance of the elements
5. Group the phenomena on the basis of essential elements into increasingly exclusive categories, and name the categories
6. Develop keys and devices as a means of recognizing and identifying phenomena

Another taxonomic problem is the extent to which the classification system design incorporates additional information, since a taxonomy must be expandable to be of continuing benefit. A good taxonomic system identifies knowledge gaps and contradictory information. Users should be able to refine the taxonomy to accommodate new information. If a differential effect is obtained for two elements in the same category, for example, the taxonomic system should allow refinement to create sub-categories.

Chambers (1969) provides the following guidelines for the development of a behavioral taxonomy:

1. Determine the use of the taxonomy; e.g., information retrieval or scientific prediction. The purpose determines which classes of variables need to be analyzed in detail.
2. Determine the content of the taxonomy. In the behavioral sciences this may involve responses, task requirements, and human functions.

3. Set up a provisional, qualitative taxonomy based on available concepts and systems.

4. After identifying the relevant variables, determine the variables operating in different situations, the values of the variables, the relations between the variables (especially the quantitative relations) and the interactions between complex sets of variables.

5. Test the reliability and utility of the system.

Methodological Approaches

Approaches to taxonomic design include content analysis, cluster analysis, behavior observation, and factor analysis. These approaches vary along a qualitative to quantitative continuum in regard to the generation of specific taxonomic units.

Content Analysis. Problems of classification in the behavioral sciences stem from the relationships among behaviors, situational variables, and antecedent conditions. Content analysis codifies behavior, therefore providing a methodology for deriving more complex behavioral classifications. The content analytic method has been used predominantly to generate data regarding communications. Content analysis is also important for organizing research information in the behavioral sciences. Detailed description and discussion of the logic and methods of content analysis are given by Berelson (1952), Pool (1959), Auld and Murray (1955) and Marsden (1965). Marsden (1965) describes three content analysis methods: classical, pragmatic, and non-quantitative.

Classical: stresses quantitative methods applied to content of communications with minimal inferences about communicators

Pragmatic: less restrictive and permits inferences about communicator implications

Nonquantitative: avoids sole use of frequency tabulations as an indicator of intensity and salience and uses alternative metrics to assess communication content.

The content analyst and the classification researcher share parallel tasks: a fundamental starting point for both is the definition of parameters or boundaries (size) of the behavior unit to be classified. Antecedent and consequent boundaries are defined within which behavior is classified. Relevant criteria for defining the occurrence of an event are determined and operationally defined along some measurable dimension (frequency, intensity, etc.).

An example of a content analytic approach to a military taxonomic goal was completed by D. Ramsey-Klee (1979), who performed a content analysis of tasks performed by job incumbents in five Navy enlisted ratings. She analyzed task statements in the Navy Occupational Task Analysis Program and linked functional duty categories to them. The descriptive results of the content analysis formed a data base for a taxonomic comparison across occupational ratings, since the analysis related the functional duty categories to occupational standards. Other development and application of the content analytic methodology has been documented by Ramsey-Klee; for example, the behavior indexing of performance evaluations for senior enlisted personnel (Ramsey-Klee and Richman, 1973, 1975).

E. E. Miller (1969) used a technique in the development of a taxonomy of response processes called "connotative clustering." His objective was to provide a classification system that related training methods to types of job requirements. He collected a large body of task descriptions from experimental literature and observation, and examined their connotative relatedness. (Connotation includes the associations or implications of words in addition to the denotation, or what the word literally means.)

The effectiveness of the approach increased as larger numbers of descriptions were examined and clustered. By listing the terms separately and then grouping them according to their connotative similarities, he formed clusters and from the clusters derived definitions of the taxonomic classes.

Behavior Observation. Behavior observation methods share some similarities with the content analytic approach. The most evident similarity is that within both systems, data are generated and coded according to descriptive dimensions applied to behavior of an individual. The central focus concerns dependent variables (behavior) without consideration of situational variables and other types of antecedents (environment); like content analysis, this approach is not interactive. Classification properties such as exhaustiveness, size of unit to be studied, etc., vary over a wide range of possibilities as does the strength of the theoretical base supporting the logic of a particular system.

Altman (1966) identifies and reviews a number of behavior observation systems for coding small group behavior, the best known being Bales's Interaction Process Analysis (1950). The behavior description approach categorizes tasks based on observations and descriptions of overt behavior. A wide variety of types and levels of description are possible. While empirically oriented, subjective descriptions are also included (e.g., inferred cognitive behaviors such as problem-solving, analyzing, and comprehending).

Cluster Analysis. Cluster analysis and taxonomies partition variables along some predetermined dimension; however, they differ in respect to level and breadth of detail. Cluster analysis is a useful tool to classify a set of variables to develop a taxonomy from those variables. The cluster analytic method reduces variances within groups, by clustering objects according to similarity. Differences within groups discerned from multivariate information can be minimized through the use of cluster analytic methods. "Three components for the empirical solution of any clustering or taxonomic problem are, (1) multivariate data which are appropriate for a particular grouping problem, (2) a measure of similarity between each possible pair of objects or variables which are to be clustered; that is, a measure of profile similarity, and finally (3) some method of cluster analysis for grouping the objects" (Ramsey-Klee, 1979, p. A-4). Cluster analysis techniques share some properties with other statistical techniques designed to analyze ordinal data (e.g., decisions regarding transformation of raw data). Cluster approaches can be hierarchical or non-hierarchical. "The non-hierarchical approaches represent the effort to group a set of objects into groups of maximum similarity. The hierarchical cluster methods permit the grouping of clusters into 'superclusters' or clusters of clusters in much the same way as the factor analysis of factors yields second order factors" (Bergin and Weiss, 1971, p. 584). The hierarchical viewpoint focuses on the relationships among the clusters. For taxonomic development, knowledge of hierarchical structure may be useful for identifying rules and principles for classification. Cluster analysis techniques are used in much of the taxonomic literature; for instance, DeNisi and McCormick (1974) use two cluster analysis procedures in the clustering of jobs on the basis of data from the Position Analysis Questionnaire (PAQ). One program (Tryon and Bailey, 1970) identified 33 job clusters with 14 general job dimensions in a sample of 3,700 jobs. DeNisi and McCormick also used a hierarchical clustering procedure to analyze and identify occupational clusters.

Sneath and Sokal (1963), in their discussion of numerical taxonomies, describe a wide range of clustering techniques for identifying similarity coefficients. Clustering and discrimination differ in that discriminant analysis identifies dimensions that maximize variation between categories while cluster analysis is oriented toward common denominators or determinants within the data set.

Clustering algorithms enjoy wide use in sorting heterogeneous data into homogeneous blocks. A principal advantage of clustering is the structure provided for interpretation and evaluation.

Factor Analysis. Factor analysis, the most quantitative of the analytic methodologies, imposes statistical rigor on previously abstracted behavioral events to identify commonalities. It is an alternative to an observation method. This method treats the prescribed data in a comprehensive fashion, encompassing the relevant classification dimensions. Beyond the boundaries of the given data few inferences can be drawn, let alone any formalized extension or extrapolation of principles; thus, the taxonomic criterion of generalizability cannot be met. The classification researcher must provide guidelines with respect to the degree of taxonomic exhaustiveness and comprehensiveness expected. Factor analysis contributes empirical support to a priori approaches, lending an inductive check to relevant dimensions, and it can identify new classification dimensions. Several successful factor analytic studies have been conducted in the small group field (Cattell, 1948, 1953; Hemphill, 1950, 1956; Borgatta, 1955, 1956; and Carter 1954). In spite of differences in measurement method and procedures, dimensions identified share surprising communality, indicating some possibility for generality and utility. As Stogdill (1959) points out, while generality of a single factor analysis is questionable, overlapping studies tapping into the same area from different perspectives can minimize the problem. The abilities requirements methods have often based their development on factor analysis. Experimental factor analytic studies of individual differences in task performance provide information through categorizing quantitatively specialized individual abilities. Tasks requiring an identifiable group of similar abilities can then be categorized accordingly. A variety of classification schemes in the abilities requirements method provide a conceptual understanding of what types and levels of factors can be derived. The classification schemes of Fleishman (1972), Cattell (1971) and Guilford (1967) indicate the diversity of factors in human performance areas. The factor analytic method is especially suited to the abilities requirements approach because of the assumption that abilities are relatively enduring, complex, and unobservable attributes of individuals.

Uses and Purposes of Taxonomies

The uses and purposes of taxonomies must be considered in order to assess the utility of specific taxonomies for ARMPREP. While a virtually unlimited number of such purposes could be delineated, a small number emerge as recurrent themes.

A central function of taxonomic systems is their ability to provide a common focus and language; thus a taxonomy can facilitate communication in a user community (Bloom, 1956). In the behavioral sciences, Cotterman (1959) stresses use of systems language to achieve a common communication base across several related disciplines.

A taxonomy imposes a conceptual frame of reference and thus organizes the subject matter systematically. Bloom (1956), working in the educational objectives area, states that his taxonomy imparts an organizational scheme, leading to an understanding of the interrelationships of its various components. This organizing frame of reference can assist the manpower or personnel planner in the analysis of Army system requirements through identification and derivation of behaviors, tasks, and the behavior-task interface.

A taxonomy is used for a specific purpose; for example, the taxonomy allows the behavioral researcher to make predictions (i.e., generate experimental hypotheses) and the policy analyst to make decisions based upon the content and structure of the taxonomy. R. B. Miller (1967) concludes that a taxonomy should assist in decision-making and predicting, rather than being an end in itself. Fleishman (1975) emphasizes the importance of the taxonomy for permitting predictions. He maintains that it is necessary to consider the relationship between that which is classified and relevant variables to achieve prediction. Fleishman explores the relationship between a weapon system component and its manpower and personnel requirements. He examines the ability of the taxonomic system to generate predictions regarding the number and type of operators and maintainers for an internal combustion engine of an Army tank. The taxonomic system guides the user down an increasingly narrow path to optimize decision-making.

The taxonomic purposes discussed to this point are fairly general and can be applied to a wide range of subject areas. At this point, it is necessary to look at specific uses of behaviorally-oriented taxonomies. According to Fleishman (1982), a human performance taxonomy is needed to link the basic and applied realms of psychological research. He identifies six major areas for which a performance or task taxonomy would be useful. In job analysis, for instance, a taxonomy could establish the similarity between new and different jobs by generating job families which have similar personnel requirements. A taxonomic system could facilitate allocating functions to people and machines in the man-machine systems design process. For personnel selection, a taxonomy could promote an accurate match of people to jobs. As Fleishman (1982) asserts, "a useful taxonomic system would include concepts linking the characteristics of job tasks, their performance requirements, and the capacities measured by selection tests" (p. 823). The other three areas identified by Fleishman are training, performance measurement, and the development of retrieval systems and data bases. An important implication is that multiple taxonomies can be created for the same subject area because they have different purposes; "Thus, there is no single criterion for classifying in any field, and psychologists need not be so sensitive about this regarding the field of human behavior" (Fleishman, 1982, p. 824).

Constraints and Limits on Taxonomies

A distinction can be made between the nature of a taxonomy and its application. While the content and structure of the taxonomy might be unassailable, it is likely to be limited in its applicability. Most taxonomic systems are developed for particular purposes and they may therefore have little value outside their initial application. For example, Colson et al. (1974) report that many well-developed taxonomies are inappropriate for classifying visual displays. They indicate that some taxonomic systems are too restrictive or narrow, while others are overly broad. This characteristic limits the applicability of extant classification systems for generating an Army MOS-related taxonomy.

Other constraints on taxonomic systems warrant attention, such as the absence of validation. Methodological and quantitative problems and lack of financial support often prevent the taxonomy developer from empirically validating the classification system. The absence of validation data limits the usefulness of extant taxonomies.

Another set of constraints has been identified by Farina (1969), who reviewed classification schemes describing human behavior in the performance of tasks. Focusing upon taxonomic systems using conceptual units such as functions, abilites and overt behaviors, Farina concludes that available taxonomies are hampered by one or more of the following factors:

1. Imprecise terms
2. Little measurement capability
3. Lack of development of a scheme to the point where it may be readily applied to real-world tasks

Colson et al. (1974) concur with this last point, maintaining that there are few classification systems which are sufficiently developed to be applied. This discussion is not intended to create the impression that extant taxonomies are wholly inapplicable to current developmental efforts; instead, it is provided to impart a balanced perspective. As stated earlier, it is expected that existing taxonomic systems, while not being entirely transferable to the present system, possess useful features which can be applied to the development of the Army MOS-related taxonomy. Generally, however, the ARMPREP taxonomy, oriented toward manpower and personnel requirements, has to satisfy several stringent conditions. Before examining these specific, formal criteria, though, it seems instructive to consider general taxonomic criteria to provide a better understanding of the basis for evaluating taxonomies.

General Criteria for Evaluating Taxonomies

A fundamental problem in evaluating a taxonomy is addressing the question of "adequacy" and determining the acceptable threshold, in terms of established criteria, that a taxonomy must attain. Altman (1968) concludes that there is no well-defined method for determining the elusive issue and compares the evaluative process of a classification system to that of evaluating a scientific theory, observing that the problems faced by both are the same in many respects. The question of identifying criteria from which a theory or taxonomic system can be assessed reduces to the problem of validation. Behavioral scientists lack agreement on where to draw the line on criterion specification. In Frank's (1957) view, only two criteria emerged as generally acceptable: a system must be logically correct, and conclusions should agree with observable facts. Kaplan (1964) believed that more extensive criteria for the validation of theories should be considered, including norms of correspondence, norms of coherence, and pragmatic norms. Kaplan defined norms of correspondence as the degree to which a theory agrees with known facts or can be verified by observations. Norms of coherence refer, first, to the fit of the theory within the larger body of established knowledge. Second, Kaplan identified the aspect of simplicity and distinguished it into descriptive simplicity and inductive simplicity. Descriptive simplicity refers to the description itself which has implications for the criterion of acceptability; however, inductive simplicity is considered more significant because it deals with the manageability of the theory. The pragmatic norm considers a theory acceptable to the extent it serves the scientific purpose for which it was designed.

Shaw and Costanzo (1970) adopted two levels of criteria for their extensive evaluation of theories in social psychology. Their first category consisted of three characteristics considered necessary if the theory is to be acceptable. Two of these are internal consistency (rejection of incompatible predictions from the same theory) and predictions from the theory must agree with known facts as well as observations made subsequent to the formulation of the theory. If the theory fits only the data upon which it is designed and lacks predictive power, it is considered to have "low antecedent probability" of being true (valid). These two criteria agree with those prescibed by Frank (1957). The third and last necessary criterion is testability. This requirement was added to account for the possibility that all known data are congruent with the theory, but the theory is untestable. For example, the psychoanalytic notion of repression defies validation although it agrees with observations. Simply, if one does not recall a traumatic experience, one is repressing it; if one does recall it, one is not repressing it. Therefore, no matter how a person responds, the behavior cannot refute the theory. While no theory in an absolute sense can be proved, a testable theory can be disproved. However, it is rare that a theory can be unequivically disproved or invalidated. The usual procedure is revision either of procedures or theoretical structure.

Shaw and Costanzo (1970) further specified five desirable (but not necessary) characteristics of an adequate theory: (1) simplicity in description and deduction, (2) economical in having few underlying principles to explain phenomena, (3) consistent with related theories that have a high probability of being true, (4) interpretable in terms of relating to real-world observable phenomena and (5) serves a useful purpose for the advancement of science. With these criteria, Shaw and Costanzo performed a comparative appraisal of social psychology theories which they grouped into six sub-areas based on subject matter. They further classified the theories according to form (constructive/principal) and content (molar/molecular). They intend such comparisons to aid theory building through identification of inconsistencies, expansion to encompass new conditions, and the identification and expulsion of less viable theories.

Deutsch (1966) proposed 15 evaluation characteristics for describing theories or taxonomies, all of which align very closely or exactly with those expounded above but in addition address taxonomies as well as theories directly. Altman (1968) has reduced the literature on evaluation criteria to six key questions to be addressed by designers and users of taxonomies:

1. Reliability. Can variables, relationships and phenomena be reliably located in the classification space? Most researchers unequivocally agree that without reliability the system is in a state of chaos. Regardless of the amount and differential characteristics of the dimensions, there is an undeniable requirement that users agree on location of items in a taxonomy.

2. Comprehensiveness. Can the classification system describe all known facts? This requirement has been most closely realized in the natural and library science schemes, due to their maturity and long institutional history. This criterion also infers mutual exclusiveness. That is, a variable or relationship is uniquely located in a classification space.

3. Elasticity. Can new facts be incorporated into the classification system? As with a theory, a taxonomy should be able to incorporate data that are generated subsequent to formulation of the system. As it becomes difficult to do so, revision is indicated. Deutsch (1966) calls this performance capability.

4. Prediction Power. Can the system predict new facts, phenomena, or relationships? What is the potential for systematic future expansion? A predictive system stimulates research through uncovering contradictions and gaps in knowledge. Altman (1966) suggests that an underlying ordering principle is necessary for

predictive capability. For instance, one must go beyond specifying classification dimensions and indicate how dimensional characteristics are combined.

Another aspect of prediction relates to differential weighting of dimensions. Due to the unwieldy number of dimensions that could be employed (no matter what the subject matter), distinctions among dimensions must be made (i.e., through some form of cluster analysis) in relation to variance accountability. This is related to the systems' functional and structural parsimony (Deutsch, 1966).

One further point to be made with regard to predictive capability is the emerging transition in the behavioral sciences from the use of bivariate to multivariate analysis methods for observing complex relationships and sequential chains of relationships.

5. User Acceptance. Is the system used and accepted by the scientific community? If a taxonomy is intended to have widespread use and application, but goes unused, then it has failed, even if it is judged to be theoretically valuable. Many reasons exist for low use of a taxonomy ranging from lack of understanding to inappropriate rejection. Deutsch (1966) augments this criterion with his concept of cost-effectiveness in such factors as training time and margin of advantage over predecessor systems.

6. Self-Transcendence (Deutsch, 1966). Does the system reproduce itself and lead to new distinctions? The system should expose internal inconsistencies and be flexible in terms of self-correction and adjustment as the nature of taxonomic unit configurations changes. Altman (1968) refers to a degree of internal creativity inherent in the system.

With these general criteria in mind, both the researcher and the user are better able to assess the overall value of classification systems.

EXAMPLES OF TAXONOMIES

The preceding sections have described the nature, development, purposes, constraints, and criteria for evaluation regarding taxonomies. At this juncture, an examination of representative classification systems is provided to illustrate the manner in which they are generated and employed. Biological, physical science, and behavioral taxonomies depict the historical development of these systems and demonstrate the manner in which advances in the science of taxonomy can enhance the generation of new ones.

According to Altman (1966, p. 48), "the behavioral sciences have not even remotely achieved the level of classification offered by Mendeleev in chemistry, Linnaeus in zoology, or Dewey in library science." Further, he acknowledges that the tremendous amount of work which preceded such systems has not yet been accomplished in the behavioral sciences. For instance, Altman notes that beginning with Aristotle's grouping of animals into families, natural scientists have labored diligently to organize vast accumulations of knowledge. The modern system, first proposed by Linnaeus in 1758, classifies animal life according to structural characteristics, which in turn are related to key life functions. This taxonomy is not simply a catalog or listing of information; rather it seeks to represent a family tree and to identify evolutionary linkages among biological organisms. As Altman (1958) observes:

> By proposing an underlying orderly principle, that is, evolutionary development, the Linneaus taxonomy enables some degree of prediction as well as description. Organizing specimens in terms of how structural characteristics fall in evolutionary lines can lead to hypotheses about missing or lost species, which can then be subject to empirical verification. Such a characteristic is important to consider in any classification (p. 54).

Mendeleev proposed the periodic law of chemistry in 1869, which was based on the assumption that properties of chemical elements are not arbitrary, but depend upon atomic structure and vary systematically with atomic number. Using atomic weight and atomic number, Mendeleev showed that elements could be arranged in a "row by column" table. The periodic table has flaws (e.g., inconsistency in column arrangement), but is open to new information and has permitted the prediction of the likely existence of undiscovered elements.

Turning from taxonomic systems in the biological and physical sciences to the behavioral sciences, some differences are readily apparent. The behavioral sciences disagree on the appropriate units of study. Altman (1968) says that despite the existence of a wealth of information concerning behavioral features, scientists lack consensus on relevant units and their structural and functional properties. Another important difference involves the data upon which the taxonomic structure is based. Unlike the biological and physical sciences, the behavioral sciences are characterized by large errors of measurement and lack of confidence regarding the reliability and validity of research findings. Any classification system constructed on the basis of empirical data in the behavioral sciences has more reliability and validity problems than systems in the physical sciences.

Having contrasted biological and physical science with behavioral taxonomies, a few illustrations of the latter systems can be provided. Taxonomies concerning the cognitive, affective, and physical or psychomotor domains of performance have been created and applied. For instance, Bloom's (1956) taxonomy of cognitive-based educational objectives is composed of knowledge, comprehension, application, analysis, synthesis, and evaluation. This hierarchical ordering is predicated on the notion that simple behaviors can be integrated with each other to form more complex behavior. Similarly, Sorenson's (1971) task behavior taxonomy includes structuring, generating, elaborating, evaluating, and requesting. In a Naval context, Powers (1971) has designed the following taxonomy based upon hypothetical job tasks:

1. Basic-nomenclature, jargon, fundamental facts related to components of equipment, hardware, and technical symbols

2. Conjoint-operating principles, functions, relationships of components of equipment/hardware system

3. Operational-operating steps for hand tools/testing equipment and primary equipment/hardware

4. Procedural-rules and procedures for assembling, dissassembling, troubleshooting, aligning, etc.

5. Multifactual-lists, tables containing specific technical data, including descriptive information on calibrations, settings, etc.

6. Configurative-visual representations of functional/operational processes

According to Powers, movement from basic to configurative tasks involves less memorization and greater reliance on abstract processes of recognition.

In the affective domain Krathwohl et al. (1964) focused on internalization processes to develop a taxonomy which incorporates receiving (i.e., attending to phenomena), responding, valuing, organizing, and characterizing. They posit that each affective dimension has a behavioral counterpart.

The physical or psychomotor domain has received considerable attention by Fleishman (1967), who has created the following taxonomies.

Psychomotor Performances Factors - control precision, multi-limb coordination, response orientation, reaction time, speed of arm movement, rate control, manual dexterity, arm-hand steadiness, wrist-finger speed, finger dexterity, and aiming.

Physical Proficiency - extent flexibility, dynamic flexibility, static strength, dynamic strength, explosive strength, trunk strength, gross body equilibrium, gross body coordination, and stamina.

In addition to cognitive, affective and physical or psychomotor systems, taxonomic structures have been developed in the area of team performance. For instance, Naylor and Dickinson's (1969) taxonomy assumes that team performance is a function of task structure, work structure, and communication structure. Task structure includes complexity, organization, and redundancy components. Work structure refers to the manner in which task components are distributed among team members and incorporates the definition of operations to be performed, the sequence in which the operations must occur, and the manner in which interactions among members must proceed. Communication structure reflects the communication interrelationships existing between team members and is determined by the task structure and work structure.

A more recent team performance taxomony has been created by Nadler and Berger (1981), who developed a classification system which identifies the following components of Navy team performance: members to coordinate, nature of task demands, team structure, leadership, and communication patterns. Within each major taxonomic category, several elements are identified to promote the differentiation of Navy teams. For example, the team member category includes experience level, proficiency level, member criticality, member motivation level, member personality attributes, and team size (an aggregation of members by various readiness conditions). Team task demands include task type, content, emergence, difficulty, and machine interface considerations. Team structure variables incorporate sequential-parallel interaction networks, interaction mode (i.e., face-to-face, audio, and machine), decision-making locus and informal structure. The team leadership function entails leader identification, leadership style, and leader-member relations. Finally, communication patterns are delineated in terms of interaction processes, task versus social communication behavior, and team cohesiveness.

Nadler (1982) has modified this Navy team taxonomy to create a taxonomy for assessing team readiness. The major components of this taxonomy are team attributes (e.g., team size, team experience), individual attributes (e.g., amount of formal training and OJT, rate, rating, and NEC/NOBC, experience in teams (general), qualifications, length of service, number of deployments, length of time on current deployment, and length of time since last deployment), operational systems (e.g., team criticality, team-equipment interface). The team readiness assessment taxonomy may contribute to the Army MOS-related taxonomy, although the focus on Navy teams and readiness and training issues rather than manpower and personnel issues may limit the applicability of this taxonomy for the ARMPREP taxonomic system. Still, the readiness assessment system appears to have utility for ARMPREP.

The preceding description of the nature, development, and evaluation of taxonomies provided an introduction to the creation of the ARMPREP taxonomy. The following sections examine the formal, specific criteria for the ARMPREP taxonomy and determine the relevance and applicability of existing classification systems to the development of this taxonomy.

REQUIREMENTS FOR THE DEVELOPMENT OF AN ARMY MOS-RELATED TAXONOMY

FORMAL, SPECIFIC CRITERIA FOR THE ARMPREP TAXONOMY

The general criteria for the development and evaluation of taxonomies provided the basis for assessing them. Certain criteria are applicable to all classification systems, while others are unique to any given one. All taxonomies should be reliable, comprehensive and predictive; however, more specific criteria are needed to evaluate existing taxonomies for ARMPREP uses. Specific criteria for evaluating taxonomies in the literature review and for developing the ARMPREP taxonomy are thus derived from a consideration of ARMPREP requirements. Examples are discrimination among Army jobs, operationally defined elements and procedures, and utility to Army subject matter experts. These and other AMRPREP specific criteria are discussed in this section.

The ARMPREP taxonomy must discriminate among Army jobs or Military Occupational Specialties (MOS). It must be useful for indicating manpower and personnel requirements for extant and emerging weapon systems, and delineate training requirements and related issues. One problem involves the desirability of having the taxonomy serve many functions that must be considered during the development of a weapon system; it is difficult to delimit the set of purposes which the taxonomy must achieve. Thus, as a practical rule, we shall focus on behaviors that characterize Army MOS, adding other considerations when they appear to be required. Eight specific criteria are proposed for the ARMPREP taxonomy.

Behavior Focus

The first formal criterion for the ARMPREP taxonomy is that it must be a classification of job behaviors. Each class of behaviors will be defined in terms of task descriptive data (TDD). Fleishman (1982) offers support for this criterion, maintaining that behavioral (response) requirements are extremely useful for classifying human task performance. The total classification system should allow for the clustering of Army MOS; that is, by identifying the behavioral requirements of a given task or set of tasks, the taxonomy should eliminate most MOS. The taxonomy should delineate a subset of MOS from the entire set of MOS which involves a match with the behavioral requirements of a position. It is desirable to make unique MOS determinations for each position, but that requirement is too stringent because frequently more than one MOS is more or less appropriate in terms of the required behaviors. Other considerations (e.g., rotation in overseas assignments) also must be included, necessitating the development of behavioral criteria which are not unduly restrictive. These considerations are often in conflict and the taxonomic system cannot be expected to completely resolve such conflicts. Finally, the TDD must be determinable during system development. This stringent requirement eliminates many extant taxonomic systems.

In focusing more specifically on this first formal criterion, it should be noted that the TDD must help to define an action (e.g., drive a truck) or class of actions (e.g., maintain a truck). The TDD cannot be merely derivative features, such as task difficulty. This assertion does not necessarily mean that task difficulty is unimportant; rather, it cannot serve as a defining characteristic of the classes of behavioral requirements.

Objectivity and Reliability

The second formal criterion regarding TDD is that they must be objective. Wheaton (1968) stresses the importance of this criterion and argues for the generation of clear operational definitions. As Ramsey-Klee (1979) notes, "the reliability with which distinctions among attributes can be made is largely a function of the extent to which they have been operationally defined" (p. A-47). Other taxonomic researchers (e.g., Christensen and Mills, 1967; Fleishman, 1982) also emphasize the important role of operational definitions in increasing objectivity. Fleishman (1982 p. 830) cites the significance of this criterion as follows:

> One of the striking findings in our review of the factor analytic literature was the difficulty in moving from the factor analyst's definition to a more operational definition that could be used reliably by observers in estimating the ability requirements of a new task.

The objective base provided by clear operational definitions is reflected in the reliability of results (i.e., different raters largely agree in their sorting of elements). As Altman (1968 p. 63) notes, "Regardless of number and character of dimensions, there is an undeniable requirement that users agree on location of items in the taxonomy. Without such reliability, the system is chaotic."

Observation Not Required

A third related criterion is that the TDD must be readily determined without direct observation; for example, a new kind of truck is known to require a driver without actually observing the truck in action. This determination is based upon knowledge acquired from past experience and the perceived similarity of the projected equipment to existing equipment. This process involves making explicit a set of categorizations and saves time and effort without degrading the TDD output. Further, early in development the equipment does not exist, so it is impossible to determine experimentally which MOS are most appropriate for the system. Even when New Equipment Training (NET) is begun, it is not feasible to try out incumbents of numerous MOS and the empirical data relate to how much transfer of training seems to exist. On that basis, a decision is made whether to "shred out" a new MOS.

Various kinds of aptitude measures are eliminated on the basis of these first three criteria. "Aptitudes" or "abilities" are quantitative abstractions which are difficult for subject matter experts (SME) to apply precisely. For instance, mechanical aptitude is mentioned in AR 611-201 as a requirement for both truck drivers and mechanics, but no discrimination in the amount of this aptitude needed for each job is made. Thus, various kinds of ability taxonomies are inappropriate for this project's purposes.

Discriminate among MOS

The fourth formal taxonomic criterion entails the ability of the TDD to discriminate among MOS. Thus, "follow safety practices" would be inappropriate, but "follow safety practices when working with high voltages" would qualify. The TDD should be sufficient in number to discriminate among MOS. As Altman (1968 p. 62) observes, the number of dimensions employed is a critical choice for the taxonomy developer, and

> Use of too few dimensions can result in underdifferentiation of the phenomena, with too many things labeled as similar. Use of too many dimensions can lead to an extraordinarily complex system (especially if all dimensions are weighted equally, with the resultant amount of information likely to overtax the absorption ability of users). Furthermore, the more dimensions the greater the likelihood that overly trivial distinctions will be present.

In this project, a classification of 20 or 30 categories will not suffice, because there are more MOS than that. In practice, the TDD are not apt to be completely efficient determiners of the MOS, so more than the minimum number are likely to be needed. Here the TDD must allow for the clustering of entities that are similar and the differentiation of a cluster from all other clusters.

Describe Army MOS Content

A fifth criterion for the ARMPREP taxonomy is that the TDD should be descriptive of Army MOS in content, level of generality, and elasticity (i.e., expandability to incorporate new elements.) For instance, the maintenance of aircraft engines uniquely defines one MOS at the support level. Many otherwise promising taxonomies fail in this respect. For example, McCormick's Position Analysis Questionnaire is useful for civilian jobs, but there are not enough TDD to relate it to Army jobs. In fact, all of the most useful models are taxonomies developed for a rather well defined purpose, even though their application may be somewhat broader than originally intended. As Sneath (1957) has suggested, the ideal classification system should possess the greatest content of information.

According to Mann (1943), an effective taxonomic system should be detailed at all levels of generality. In addressing the problem of developing a classification system of human performance, Fleishman (1982) argues that the majority of categories in common use (e.g., cognitive, motor, perceptual, etc.) are too general, whereas derivatives of factor analysis (e.g., rotates knob control) are too specific. The level of generality for the ARMPREP taxonomy should be at the MOS level (or perhaps somewhat below), but generally not down to the "switch-turning" level. The description of MOS in AR 611-201 is a fruitful starting point, although it may be supplemented with TDD based upon classes of tasks (but rarely down to the task level). For example, if several items of equipment are maintained by one MOS, another item of the same class is apt to be maintained by the same MOS, unless it is drastically different in some way from other members of the class. In this case, it might be necessary to determine what characteristics define the boundaries of that class of equipment. Another way of obtaining that information involves asking SMEs whether the new equipment differs appreciably from members of the class, as well as the nature and importance of these differences.

The third aspect of describing Army MOS entails the requirements of elasticity, where elasticity refers to the ability to incorporate new items. A general system development taxonomy with modular components that are organized for a given developmental item has been proposed for this reason. This approach not only permits any developmental item to be addressed, but is sufficiently flexible to allow for personnel requirements which cannot be envisioned. The capacity for expansion is characteristic of an ideal classification system, and a taxonomy has limited potential without it. A viable taxonomy reproduces itself and leads to new distinctions (Altman, 1968; Mann, 1943); thus, the ARMPREP taxonomy should be elastic.

Familiar Terms

The sixth taxonomic criterion is that the TDD should be expressed in familiar terms for SMEs who are analysts for developing systems. Taxonomic units must be readily comprehensible and acceptable to the users. For example, R. B. Miller (1971) proposes a user-oriented approach for developing new ways of describing and analyzing tasks and duties. A user orientation also requires acceptance of the taxonomic model by the workers in the field if it is to be regarded as a useful and effective tool (Bloom, 1956). In developing his classification system of educational objectives, Bloom believed that distinctions between taxonomic classes should reflect those which teachers make among student behaviors. Wheaton (1968) and Altman (1968) also identify degree of user acceptance as a salient criterion.

Consistent with Army Regulations and Practices

The seventh criterion is an outgrowth of the preceding evaluation factor. Specifically, the TDD should be technically defensible in terms of hardware systems, regulations, and Army practices. The TDD should be consistent with the MOS structure as enacted by Army systems planners and analysts. This requirement does not preclude taking exception to those conventions when it appears necessary, but this action would require justification and approval.

Facilitate Decisions

The final taxonomic criterion is that the taxonomy should facilitate decisions that otherwise would be inaccurate or omitted. The classification system should accomplish an objective that would not be possible or likely without it. Each task descriptive datum should contribute to the system by allowing more precise categorization. For example, the defining characteristics of Army MOS may appear trivial when considered in isolation, but so many must be considered that they exceed human memory, necessitating systematic procedures. For instance, during development of a new kind of vehicle, an analyst may anticipate the number of truck drivers needed to transport the fuel, but if the total manpower requirements are put into a computer, the analyst may forget to adjust the number of truck drivers when fuel consumption turns out to be greater than anticipated. When this element is considered in the context of the overall system, its implications for manpower and personnel requirements clearly emerge. All of the taxonomies reviewed met the criterion of facilitating decisions.

While these criteria may eliminate most or all existing taxonomies in terms of their transferability to the ARMPREP system, they do provide the necessary focus for examining these taxonomies. Although extant taxonomic systems are not wholly applicable for this project's purpose, they might contain useful distinctions and methods. Thus, the literature review explored existing taxonomic systems for their utility in the development of the ARMPREP system. The method employed for identifying, grouping, and analyzing existing taxonomies is described in the next section.

METHOD FOR EXAMINING EXISTING TAXONOMIES

Literature sources include published bibliographies, human factors journals, NTIS, DTIC and RDIS searches, and others dealing with taxonomy and classification approaches and issues. The taxonomies or taxonomy-related literature reviewed fell into three broad areas: Those taxonomies that contribute to the refinement of taxonomic theory and process, but are peripheral to ARMPREP; those exemplifying the approaches identified as significant in the literature (i.e., the four historical approaches described by Altman, 1966 and McGrath and Altman, 1966); and those from the social sciences that contribute a conceptual approach. This literature was reviewed to assess the state of the art in classification systems or taxonomy approaches and guide the development of a system-centered, self-generating taxonomy of processes (behavioral requirements) intrinsic to Army weapons systems and leading to the isolation of certain crucial human resource requirements. With this in mind, we reviewed taxonomic systems and compared stated goals and the degree to which those goals were achieved in terms of end-products, approach, types of taxonomic units generated, interim steps, and correlation with appropriate variables. Most classification systems demonstrate a mixed qualitative and quantitative approach to classification based on the presence or absence of critical attributes or according to the degree of intercorrelation of units with selected variables. A second purpose of this review is to extract and incorporate elements useful for ARMPREP.

The survey of existing classification systems was conducted in two parts. First was an examination and evaluation of approaches which have been used historically, and second was exploration of specific taxonomic systems, organizing them according to categories which reflect the taxonomic literature. The results are presented in the next two chapters.

APPROACHES TO TAXONOMIC SYSTEMS IN THE BEHAVIORAL SCIENCES

IDENTIFICATION OF APPROACHES

The first section of this review identified the following six major approaches to classification: task characteristics, behavior requirements, behavior description, ability requirements, information theory, and phenomenological methods (Altman, 1966, Hays, 1981; McGrath and Altman, 1966). This section describes each approach and the next section assesses the utility of each for ARMPREP.

Task Characteristics

The task characteristics approach is unique in that it classifies tasks using descriptions which are independent of human traits. A task is defined as a set of conditions which elicit performance, and is described in terms of objective properties. As Fleishman (1982, p. 829) suggests, "the model characterizes tasks in terms of general components of goals, procedures, stimuli, responses and their relations." These general components are categories for task characteristics or descriptions (e.g., number of output units, number of procedural steps, degree of operator control). Using Farina's (1969) equation for determining task performance, this approach stresses the task while acknowledging the importance of operator and environmental features. For example, different tasks evoke different activities, place demands on various configurations of abilities, and require different types and sequences of processing. This approach posits the existence of task characteristics wholly independent of the human activities they trigger or the abilities they require.

The task characteristics approach is widely used by behavioral scientists (e.g., Cotterman, 1959; Fitts, 1962, Stolurow, 1964; Wheaton and Mirabella, 1972; and Farina and Wheaton, 1973). As Fleishman (1982) notes, this aproach has proceeded to the measurement stage, with some empirical evaluation. Task characteristics have been cast into a rating-scale format with reliable scales. Validation studies show that ratings of the task characteristics correlate with task performance; subtle differences among task characteristics can be described and related systematically to variations in task performance. The task characteristics approach describes features which influence task performance and suggests how these features can be modified to enhance such performance.

Behavioral Requirements

The behavior requirements approach is closely related to the task characteristics approach, and in some respects is derived from it. This approach catalogues behaviors needed to achieve criterion levels of performance, such as the rapidity, force, and duration for which a lever has to be pulled to adjust pressure to its desired level. It assumes that the human operator has a large repertoire of processes that intervene between stimulus events and output events (the input and output configurations require certain intervening processes or functions). Like the task characteristics approach, the behavior requirements approach uses Farina's (1969) performance algorithm and stresses task demands.

Many task descriptive taxonomies are based upon the behavior requirements approach (e.g., Gagne, 1962; R. B. Miller, 1962; Annett and Duncan, 1967). Considerable interest has emerged in codifying the intervening processes (functions, behavior, etc.), cataloging tasks as to the types of processes required, and relating the types of tasks to particular training methods. These systems generate lists of the behavioral processes in task performance, consider techniques for their detection, and specify additional factors (e.g., sequencing of behaviors, time constraints, etc.) which should be considered for a complete description of tasks in behavioral terms.

Unlike the task characteristics approach, this system is attractive because of the economy of description it affords. Like the task characteristics approach, the behavior requirements approach does not require direct observation for the development of a valid and reliable classification system. Both approaches are analytical in nature; thus, they are compatible with analyses of systems into subsystems and lesser components. Whereas the task characteristics approach deals with objective task dimensions, the behavior requirements approach focuses on intervening behavioral processes. Generally, both approaches contribute to the developing of a taxonomic system which derives behavioral requirements from task descriptive data.

Behavior Description

The behavior description approach is based on observations and descriptions of what operators do while performing a task. Most of the behavior descriptive schemes result from "attempts to relate task behaviors to the conditions of training, to select optimal methods and measures of job performance, to specify interactions between people and machines, or determine occupationally-related education" (Fleishman, 1982, p. 829). Examples of a behavior descriptive approach include Berliner et al. (1964), Chambers (1969), Alliusi (1967), Mecham and McCormick (1969), and Fine

(1964). The operator is the primary focus of the behavior description approach. Overt behaviors in response to the task are analyzed rather than what is required to reach some specified criterion level. The possible variations are almost infinite because of the variety of levels that lend themselves to description (dial setting, decision-making, etc.). Questions which arise include: How detailed should the description be? How are determinations made regarding the parameters of criticality or representativeness of activities involved in task performance?

One drawback of this approach is the requirement for direct observation, an unwieldy task if the body of data is large. As the level of data addressed goes beyond the molecular (task), the possibility for an orderly, systematic description decreases. Many behavior descriptive systems lack rigor and are highly qualitative and general, thereby lacking generalizability in applying principles across tasks (Meister, 1976; Teichner & Whitehead, 1971). The behavior description approach arose from scientific attempts to quantify differences in human ability. In that respect, this approach lays the groundwork for many of the other approaches. Behavior description provides inferences with regard to ability requirements, behavior requirements, task characteristics, or any other behavior-related aspect of the person-task-environment interaction. The behavior description approach is germinal in the development of the other approaches but is not directly applicable for the purposes of the present project.

Abilities Requirements

The abilities requirements approach develops a taxonomy by describing the abilities which a task requires of the individual performer. Abilities are assumed to be enduring traits of the individual and certain tasks are assumed to require certain abilities; thus, tasks are analyzed to determine ability requirements along quantitative and qualitative dimensions (i.e., type and amount of ability required). Descriptive labels are derived from factor analytic studies and the resulting taxonomic units are considered to be more basic than the functions and processes posited in other taxonomic approaches (e.g., the behavior requirements approach). The classification schemes of Fleishman (1967), Guilford (1967), Thurstone (1944) and Harrow (1972) generated lists of abilities within the perceptual motor, psychomotor, cognitive and perceptual domains. Factor analysis and some other forms of componential analysis are used in generating and clustering units of behavior according to the abilities required for performance. Similar to the behavior description approach, the problem emerges of choosing critical or representative parameters. A complex task may require a number of abilities of varying degrees from which the researcher is supposed to determine a hierarchy. This approach, like the behavior description approach, focuses on abilities of the operator.

Abilities are inferred from factors, and semantic distinctions are achieved by a "labeling" process. This process begins with the researcher analyzing patterns of response consistencies associated with a particular factor and then developing a set of hypotheses with regard to the common denominator indicated by factor loadings. This "commonality" is labeled semantically in a way that the researcher believes is representative of the commonality indicated in the factor. This inferential leap from the empirical-mathematic analysis to the labeling process must be clearly understood in evaluating this approach for an application focused on a task or system classification continuum. Task analysts may have difficulty in associating the abilities required with the task elements which demand them. In a two-part study by Theologus et al. (1970, 1971), task analysts had difficulty during the first study reaching agreement as to the extent abilities (indicated by factor loadings) were associated with task performance. During this exploratory phase, ability definitions were revised and the rating technique improved to the point that reliable, ability-based scales were demonstrated. The second part of the study (Theologus et al., 1971) confirmed the earlier reliability and demonstrated construct and predictive validity. These investigators and others involved in the linking of human abilities to work performance have paved the way for closing the gap between two very distinct taxonomic worlds. The ability requirements approach has been found applicable to a variety of problems in both civilian and military life.

Information Theory

The information-theoretic approach treats tasks in terms of the transfer of information between system components (e.g., man-machine, man-man, or machine-machine). As R. B. Miller (1971) notes, this approach views the individual as an information processor capable of coding one class of information into other classes of information. Levine and Teichner (1971) postulate that classes of tasks are characterized by classes of constraints, which are divided into those acting upon the source (input) and upon the receiver (output) of the information. Tasks are categorized by the amount of redundancy in information transmission and by the relationship between input and output certainty. Using Farina's (1969) model of task performance, the information-theoretic approach emphasizes the interaction of task and environmental features.

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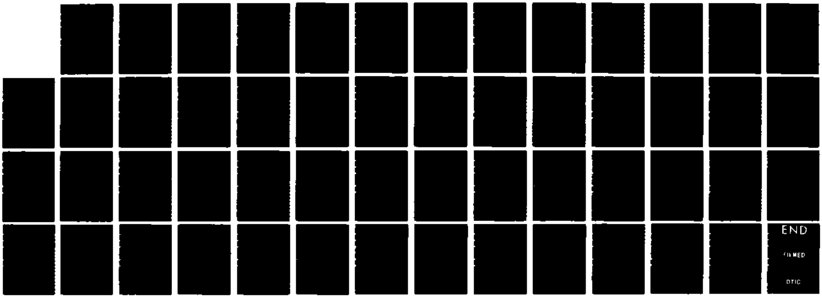

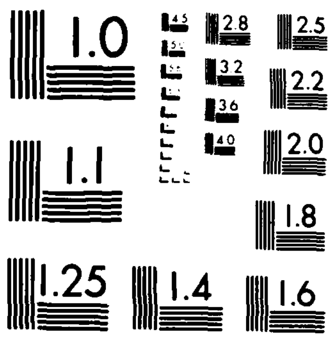

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Levine and Teichner (1971) present a two-step, iterative procedure for evaluating an information-theoretic model. First, computer simulations are performed to ascertain the relationship between redundancy and transmitted information under a variety of constraint combinations. Next, they advocate empirical investigations using tasks which allow the experimenter to manipulate input constraints and require the subject to provide output constraints.

As Ramsey-Klee (1979, p. A-25) observes, "This information processing model for task classification has the potential of predicting performance on tasks which have not yet been researched and for hardware that is not yet built," and that the integration and generalization of human performance research results can be facilitated by this classification scheme.

Phenomenological

The phenomenological approach to task classification focuses upon the manner in which the task is experienced by the individual. The application of Farina's (1969) task performance algorithm reveals that this approach emphasizes the human operator while treating task and environmental factors as elements which impact upon the person's experiential field. Klein (1977) identifies the following two components of this approach: wholistic understanding of the task and shifts in perspective. The first component refers to the attainment of an overall awareness of task character (i.e., a system-oriented viewpoint rather than one entailing the compartmentalization of task components), while the second component involves acquiring the perspective needed to accomplish a task effectively. As Klein (1977, p. 8) notes, "It is assumed that by having the trainee learn to experience a task in a similar way to the expert, the trainee's performance will take on some of the performance characteristics of the expert; e.g., smooth and integrated performance." This attribute entails the ability to assume other crew members' perspectives to enhance crew coordination performance. Klein's identification of motor analogies might serve well as a basis for grouping tasks. Klein suggests that a phenomenological approach is beneficial for tasks which are characterized as non-procedural, complex, and not easily depicted by a linear sequence of required actions.

ANALYSIS OF APPLICABILITY OF THESE TAXONOMIC APPROACHES

Having described these major approaches to the classification of tasks, it is possible to examine their utility for the ARMPREP taxonomy. In this regard, it should be realized that the taxonomy of taxonomic systems, as discussed earlier, will serve as the organizing framework for the literature review, which in turn will provide significant input to the development of an Army MOS-related taxonomy. Therefore, this section explores the adequacy of the six approaches to task classification.

At the outset, it must be acknowledged that the evaluation of these approaches, rather than focusing upon their intrinsic value, will be based on their capacity to make substantive contributions to this project's purposes. While these approaches vary in regard to the type and level of data they address, this diversity is beneficial in that many different methods for describing and classifying tasks are represented. Another consideration in assessing the utility of these task classification systems for the development of the ARMPREP taxonomy involves the methodological focus they provide. Although these approaches may lack explanatory power when viewed as analytic systems, they do offer insight regarding the treatment of taxonomic data. Given this overview of the potential contributions which these approaches can make to the ARMPREP taxonomy, we now turn to factors which might limit their applicability in the context of this project's requirements.

A major drawback of the six task classification approaches is their inability to address the system level (i.e., MOS) which must be described in developing the ARMPREP taxonomic system. For example, the behavior description approach is far too general for ARMPREP, whereas the abilities requirements approach does not correspond to the MOS level of task description. The phenomenological approach does not provide performance criteria for complex tasks, but relies upon subjective judgments and ratings (Klein, 1977). A similar analysis reveals shortcomings of the other approaches, too, thereby rendering them inapplicable for generating the ARMPREP taxonomy. This finding is not surprising because, as Hays (1981, p. 8) notes, "Each has a different goal and produces a different form of output."

Another critical factor in determining the utility of these approaches involves their major focus. They stress one or more elements of human performance and downplay the role of other important elements. Here, Hays (1981) indicates that "the distinctions between the approaches are important because by choosing one approach over the others, we are likely to obtain different results. These various results are due to the different criteria each approach applies to the analysis of the task" (p. 8). Using Farina's (1969) paradigm, it is evident that each of the six task classification approaches emphasizes one or more of the elements of human performance, while de-emphasizing some other elements. The behavior requirements and task characteristics approaches stress task elements, while the phenomenological, behavior description, and abilities requirements approaches emphasize the human operator. Finally, the information-theoretic approach emphasizes the task and environmental features. Each approach gives inadequate consideration to other elements. This criticism is not intended to devalue the inherent worth of these approaches, but to indicate that no single approach is entirely transferable to the ARMPREP taxonomy. A broader, more flexible organizing framework is required to ensure maximum utility of the literature review for the generation of the ARMPREP taxonomy. The follwing section provides that structure and evaluates specific taxonomies.

SPECIFIC TAXONOMY REVIEW

This section organizes taxonomies into the following three categories: general behavioral taxonomies, taxonomies which serve as part of a methodology, and specifically applied taxonomies. General behavioral taxonomies focus upon broad principles (e.g., learning) and are intended to have a wide range of application. They are not single-purpose, but instead apply to many subject matter areas. The second category contains taxonomies that serve as methodological tools. They facilitate the analysis of a phenomenon by assisting in operational definition and measurement (e.g., task and training analysis). Finally, some taxonomies apply to a specific problem, problem area, or narrow issue. The following pages identify and describe some representative taxonomies within each of the three categories in terms of their applicability to the development of the ARMPREP taxonomy.

GENERAL BEHAVIORAL TAXONOMIES

Fleishman's Taxonomies

The work of Fleishman and his associates at the American Institutes for Research is representative of the first category, general behavioral taxonomies. Their research identified human abilities via correlational/factor analytic research, to develop and verify taxonomic systems for the classification of human task performance. Factor analytic techniques were employed to determine the set of abilities underlying successful task performance. The primary goal was to obtain the fewest independent ability categories which described performance in the widest variety of tasks.

Their work enhanced the ability to relate performance observed in one task to that observed in other tasks. Ramsey-Klee (1979, p. A-16) summarizes this research in the following manner.

> The purpose of the taxonomy project conducted by American Institutes for Research is to develop and evaluate systems for describing and classifying tasks which can improve generalization of research results about human performance and to develop a common language for communication between researchers and individuals who need to apply research to personnel problems.

Fleishman and his associates investigated more than 200 different tasks administered to thousands of subjects, and identified eleven psychomotor performance factors and nine physical proficiency dimensions. A list and description of these 20 factors is provided in Tables F-1 and F-2.

This performance taxonomy represents a significant accomplishment because of its actual and potential contributions to the enhancement of systems performance. It has achieved success in linking human abilities with the diverse tasks performed in a variety of settings. This achievement has direct relevance for considering the personnel selection and assignment processes required in fielding a new weapon system, since determination of the ability requirements for operating and maintaining the weapon system can facilitate the process. Specifically, the abilities identified as required for a particular task can be matched with

- o task characteristics - to identify early, based on groupings of task-ability relationships, what the abilities are
- o data on soldiers' capability levels to make selection decisions.

The applicability of Fleishman's system for the development of the ARMPREP taxonomy, however, is limited for various reasons. First, it focuses at a too molecular level upon the specific abilities required by a given task. Instead, an emphasis on task descriptive data is required to make MOS-level decisions. Although the abilities requirements approach typically necessitates behavior observation activities, Fleishman's approach requires only expert knowledge of the task. Still, the lack of a behavioral focus is a limitation for ARMPREP's purposes. Finally, the ability requirements approach, which is predicated upon factor analytic techniques, can lack an objective base as evidenced by the semantic difficulties involved in labeling the factors. Although a cluster of elements may have several common properties, it is inevitably summarized using a single label. While subsequent investigators may be able to reproduce the cluster or clusters, it is unlikely, given a variety of commonalities among elements, that these investigators will attach the same category label to these elements. Also, it should be acknowledged that, in a tautological manner, the operational definition of a factor hinges upon the label attached to that factor. Thus, the semantic problem involving the labeling of factors may negatively impact upon the reliability of the taxonomic system. Still, it must be noted that the ability requirements approach has yielded sizeable reliabilities. For example, Mallamad et al. (1980) obtained interrater coefficients of approximately .80.

Although this ability-based taxonomy is not directly transferable to ARMPREP, it can be useful in guiding the development of the ARMPREP system. In linking human abilities and task demands, Fleishman's taxonomy provides a useful structure for considering task performance. Specifically, it can help establish a relationship between the behavioral requirements of tasks and the capabilities of available manpower and personnel resources. In this manner, it can serve a guiding function for making manpower and personnel-related decisions. While the behavior requirements and

Table F-1

PSYCHOMOTOR PERFORMANCE FACTORS*

1. Control Precision -	finely controlled muscular adjustments, such as moving a lever to a precise setting.
2. Multi-limb Coordination -	ability to coordinate the movements of the limbs simultaneously, such as packing a box with both hands.
3. Response Orientation -	ability to make quick and accurate movements in relation to a stimulus, such as reaching out and flicking a switch when a warning horn sounds.
4. Reaction Time -	elapsed time between the appearance of a stimulus and a response, such as pressing a key in response to a bell.
5. Speed of Arm Movement -	speed of gross arm movements, not requiring accuracy, such as gathering trash and throwing it into a large pile.
6. Rate Control -	ability to make continuous motor adjustments in response to a moving target changing in speed and direction, such as holding a rod on a moving rotor.
7. Manual Dexterity -	skillful arm and hand movements in handling fairly large objects under speeded conditions, such as placing blocks rapidly into a form board.
8. Finger Dexterity -	skillful manipulations of small objects, such as nuts and bolts, with the fingers.
9. Arm-Hand Steadiness -	ability to make accurate arm-hand positioning movements not requiring strength or speed, such as threading a needle.
10. Wrist-Finger Speed -	wrist-flexing and finger-tapping movements, such as transmitting a continuous signal with a telegraphic key.
11. Aiming -	an ability defined by a test to place dots in circles as rapidly as possible.

*Adapted from Dunnette, 1976, p. 484

Table F-2

PHYSICAL PROFICIENCY FACTORS*

1. Extent Flexibility -	ability to flex or stretch trunk and back muscles.
2. Dynamic Flexibility -	ability to make repeated, rapid, flexing trunk movements.
3. Static Strength -	ability to exert force against objects for a brief period of time.
4. Dynamic Strength -	ability of muscular endurance in exerting force continuously or repeatedly.
5. Trunk Strength -	ability to resist fatigue, involving the trunk and abdominal muscles.
6. Explosive Strength -	ability to mobilize energy effectively for bursts of muscular effort.
7. Gross Body Coordination -	ability to coordinate action of several body parts while body is in motion.
8. Gross Body Equilibrium -	ability to maintain balance with non-visual cues.
9. Stamina -	ability to sustain maximum effort requiring cardiovascular exertion.

*Adapted from Fleishman, 1972, p. 1020

ability requirements approaches are oriented differently, it should be realized that they have similar ends. Also, as Dunnette (1976) reports, this approach highlights the fact that the acquisition of motor abilities for job performance involves different skills at different stages of practice. Here, Fleishman's work suggests certain patterns of relationships among human abilities. For example, a typical finding is that proficiency in early phases of learning a new task is related most closely to non-motor factors, with motor factors increasing in performance as practice decreases. Obviously, this research finding has significance for the development and administration of training programs. Another important contribution of Fleishman's research entails casting human performance as a dependent variable and examining the impact of certain independent variables upon performance. Specifically, Fleishman (1967) asserts the need to develop principles of kinds of treatments, environmental factors, and procedures that affect human performance. Fleishman's taxonomic system is viewed beneficially as a general behavioral taxonomy because of its potentially broad range of application and utility.

Job Assessment Software System

Fleishman's taxonomic work regarding human abilities has recently been extended and applied by Rossmeissl et al. (1982 a). They examined the perceptual and psychomotor aptitudes discussed above, as well as the cognitive aptitudes generated by Ekstrom et al. (1976) of the Educational Testing Service. Overall, 40 basic human abilities were identified and explored in terms of their relationship to performance on a wide range of tasks. This taxonomy served as the basis for developing a flexible and easily implementable technique which allows weapon system designers and planners to specify the abilities required to perform system operation and maintenance tasks. These ability requirements can then be used to determine whether the human resource pool can supply sufficient personnel for system operation. Drawing upon Mallamad et al.'s (1980) development of a binary decision flow structure for identifying the ability requirements for tasks on jobs, Rossmeissl et al. (1982 a) computerized the taxonomic system. They created the Job Assessment Software System (JASS), which consists of the following three elements:

1. Binary decision flow branching network for ability specification
2. Capability to produce and display a variety of rating scales and task examples for ability rating
3. Data aggregation, processing, reduction, and analysis routines to summarize system aptitude requirements

This automatic system thus supplements the binary decision structure with rating scales which quantify the relative level of a particular ability required to perform the job or task being analyzed. These scales permit the rater to select a score ranging from 0 to 17, with sample task descriptions (i.e., anchor points) provided to assist the rater in assessing a specific job. Rossmeissl et al. (1982a) modified Fleishman's anchor points to be more suitable for widespread Army use.

JASS is composed of the following programs: job assessment, job assessment review by the rater, job assessment review tally, job assessment revision, anchor point development, and anchor point development scores. Further, JASS is divided into career field packages, such as automotive mechanic and helicopter crewman (Rossmeissl et al., 1982b). JASS is intended as a technique for use during the early stages of weapon system development to facilitate the assessment of ability requirements associated with the operation, maintenance, and support tasks inherent in new equipment design. In this regard, Rossmeissl et al. (1982) indicated that the primary evaluation criteria for JASS are ease of operation (i.e., user acceptance) and demonstrated validity of results. They gathered data on user acceptance at two weapon system production companies, obtaining some support for this criterion. While JASS has not undergone validity testing, the two corporations mentioned above did question the capability of JASS's 40 abilities to define the requirements of a wide variety of military jobs. Based upon this preliminary testing, Rossmeissl et al. (1982a) recommended these modifications to JASS:

- Improve user acceptance
- Improve validity and reliability
- Improve programming efficiency
- Determine the most appropriate types of anchor points
- Develop the capability for the software to "learn" about weapon systems through accumulated user inputs.

This system offers promise for determining manpower/personnel requirements from human abilities, and the researchers have created a user's guide for implementing the JASS procedures.

Bloom's Taxonomy of Educational Objectives

Another general behavioral taxonomy has been developed by Bloom and his associates in the area of educational objectives. This taxonomy is applicable to a wide variety of learning-oriented purposes (e.g., generating behavioral objectives, determining course curricula and method of presentation, and assessing student performance/progress). Bloom (1956) contended that a behavioral base, which represents an important taxonomic requirement, could be achieved by stating educational objectives in a behavioral form. He maintained, therefore, that these behaviorally-oriented objectives have their counterparts in the behavior of individuals, which can be observed and described. "This taxonomy is designed to be a classification of the student behaviors which represent the intended outcomes of the educational process" (Bloom, (1956, p. 12). Neither detailed observation nor experimental data is needed to generate the educational objectives. Instead, Bloom's taxonomic system is based upon the classification of descriptive statements regarding three parts: cognitive, affective, and psychomotor domains. This discussion focuses on the first of these three domains.

The cognitive domain entails recall or recognition of knowledge and the development of intellectual abilities and skills. Focusing upon educational, logical, and psychological considerations, a hierarchical taxonomic structure was created to enable the user to understand more clearly the place of a particular objective in relation to other objectives. The cognitively-based taxonomy of educational objectives is displayed in Table F-3.

Bloom's taxonomic system satisfies several of the formal criteria for the ARMPREP taxonomy. It identifies behavioral requirements, does not necessitate observation, is non-trivial, and appears to be objective. It serves as a useful model for developing the ARMPREP taxonomic system. Of course, its focus upon educational objectives has little relevance for the purpose of making personnel decisions concerning emerging weapon systems. It does not address Army MOS, is unfamiliar to most Army planners, and is

Table F-3
TAXONOMY OF EDUCATIONAL OBJECTIVES*

1.00 KNOWLEDGE - recall of specifics and universals, methods and processes, or of a pattern, structure, or setting.

- 1.10 Knowledge of Specifics
  - 1.11 Knowledge of Terminology
  - 1.12 Knowledge of Specific Facts
- 1.20 Knowledge of Ways and Means of Dealing with Specifics
  - 1.21 Knowledge of Conventions
  - 1.22 Knowledge of Trends and Sequences
  - 1.23 Knowledge of Classifications and Categories
  - 1.24 Knowledge of Criteria
  - 1.25 Knowledge of Methodology
- 1.30 Knowledge of the Universals and Abstractions in a Field
  - 1.31 Knowledge of Principles and Generalizations
  - 1.32 Knowledge of Theories and Structures

2.00 COMPREHENSION - understanding or apprehension in which the individual knows what is being communicated and can use it without relating it to other material or seeing its fuller implications.

- 2.10 Translation
- 2.20 Interpretation
- 2.30 Extrapolation

3.00 APPLICATION - use of abstractions in particular and concrete situations.

4.00 ANALYSIS - breakdown of a communication into constituent elements so that the relative hierarchy of ideas is made clear and/or the relations between the ideas expressed are made explicit.

- 4.10 Analysis of Elements
- 4.20 Analysis of Relationships
- 4.30 Analysis of Organizational Principles

5.00 SYNTHESIS - forming elements and parts into a whole.

- 5.10 Production of a Unique Communication
- 5.20 Production of a Plan, or Proposed Set of Operations
- 5.30 Derivation of a Set of Abstract Relations

6.00 EVALUATION - judgments about the value of material and methods for given purposes.

- 6.10 Judgments in Terms of Internal Evidence
- 6.20 Judgments in Terms of External Criteria

* Adapted from Bloom, 1956, pp. 201-207

not technically defensible in terms of hardware systems, regulations, and Army practices. Therefore, the major contributions of Bloom's taxonomy are the process of deriving taxonomic elements and the elegant structure which depicts the complex interrelationships among the elements.

Gagne's Human Learning Categories

A third general behavioral taxonomy is Gagne's system of human learning principles. Gagne (1962) asserts that an individual behaves in a system "as a data transmission and processing link inserted between the displays and controls of a machine" (p. 37). Thus each human function can be described in terms of input-output transformations. According to Ramsey-Klee (1979), this scheme conceptualizes all human functions as combinations of the following three basic functions:

> Sensing - the presence or absence of a difference in physical energies.
>
> Identifying - an operator makes a number of different responses to various classes of stimulation.
>
> Interpreting - the identification of meaning of inputs and the generation of outputs based upon those meanings.

As Hays (1981) notes, "The description of one or more of these three functions can provide a basic definition of the tasks which any simulator is designed to train" (p. 13). The link of these basic functions to task definitions is important. Hays contends that the description of these functions should detail the necessary inputs and the required outputs or responses for a particular activity. While inputs usually involve displays and/or other informational cues, the description of outputs is more difficult because of their greater diversity. Outputs can be classified as unitary responses, autonomous sequences, and flexible sequences (Gagne 1962). In this context of training simulators, Gagne (1965) has formulated his taxonomy of cumulative learning sequences. The six taxonomic categories are listed below.

- o Stimulus-Response Connections
- o Chain of Relationships (motor or verbal)
- o Multiple Discriminations
- o Concepts
- o Simple Procedures or Rules
- o Complex Principles or Rules

This taxonomic system is hierarchically arranged in the sense that learning at any given level subsumes learning at all lower levels. As McCormick (in Dunnette, 1976) observes, this scheme assumes that any given task can be classified in terms of one of these categories. Gagne's taxonomy has been applied in designing simulators for the following types of tasks: procedures, motor skills, identification, conceptual tasks, and team functions.

Gagne's taxonomy is useful for ARMPREP for two major reasons. First, his categories of learning can be operationally defined in action statements. This congruence with the behavior requirements approach is beneficial for developing the categories of the ARMPREP taxonomy. These requirements can be determined without detailed observational activities. Second, as Gagne's work has focused largely upon military training simulators, it is probably reasonably familiar to Army planners. Gagne's taxonomy is not entirely transferable to the ARMPREP system, however, since it has a much broader view than the MOS level of description required for the ARMPREP taxonomy. Thus, it could not be used to discriminate successfully among Army MOS.

Cotterman (1959), Fitts (1962), and Stolurow (1964) exemplify the concern of many of the early learning theorists in attempting to devise classification schemes which rationally organize and structure learning principles in a way that directly relates to human task performance. It was their objective to use such a system to improve training, both in terms of deriving more efficient methods and the discovery of underlying principles. To generate these schemes, these three theorists used the task characteristics approach concentrating on the processes and functions evoked by the task.

Cotterman's (1959) model had three sets of independent variables: input, output and intervening relationships. These sets of variables were divided into basic, task, and subject variables. Basic variables were directly related to learning and had a constant presence, but in varying degree (e.g., motivation.) Task variables distinguished differences among tasks. Subject variables represented ways in which individual subjects differ, consequently displaying differences in learning behavior. Cotterman hypothesized an interaction between basic and task variables. This systematic expansion was limited to the extent that the three categories of variables were not mutually exclusive. Cotterman strongly encouraged the use of systems language and stressed the importance of a common base of communication across disciplines. It is this emphasis on a common systems language as well as the general usefulness of harnessing the principles available in the vast learning literature for application to problems of human performance which gives this effort particular historical significance.

Fitts (1962, p. 178) proposed a broadly applicable classification system for skilled tasks: "A taxonomy should identify important correlates of learning rate, performance level and individual differences. It should be equally applicable to laboratory tasks and to the tasks encountered in industry and in military service." He stressed the dynamic character of task classification and suggested a taxonomy for "processes and activities, rather than for static elements." He viewed task performance as an ever-changing interaction of man, machine and environment, and described skilled performance according to the following three characteristics:

- o spatial, temporal patterning,
- o continuous interaction of response process including input and feedback processes, and
- o learning.

Fitts's task characteristics approach grew out of experimental research literature and the experiences of instructors. The task taxonomy introduced by Fitts deals with skilled tasks and their performance in a two-phase system. In the first phase, features of skilled tasks are classified to:

the degree of gross body involvement, and

the degree of observable dynamics characterized by the activity.

These two factors underlie skill "constancies" which pervade behavior patterns producing skilled behavior. The hierarchy of description moves from simple to complex in three stages.

- o The individual initiates a behavior pattern from a resting position in a relation to a relatively fixed or stable set of environmental objects; e.g., threading a needle, picking up an object. In this stage behavior is relatively easy to observe and measure.
- o In the next more complex situation, behavior is initiated while either the body or the external objects are in motion, e.g., batting at a thrown ball. Uniformities of the behavior patterns shown by the individual become more difficult to observe.
- o The most complex level of skill constancy involves both the individual and the external environmental objects in motion prior to initiating the skilled behavior sequence; e.g., a football quarterback throwing a running pass. From this kind of activity, it would be

> extremely difficult to identify and record temporal spatial patterns of motion or extract constancies underlying such actvities.

From this gross skilled task classification, Fitts sets the stage for the more detailed system considering man, machine and interacting environment in an ever-changing closed loop system. Within this system, inputs, outputs and feedback loops represent the major interactions in skilled performance, from the proprioceptive cues to the man-machine interactions. Within this scheme, Fitts emphasized the potential for specifying major characteristics and the extent of their involvement in dynamic patterns of skill-directed activities. A comprehensive application was envisioned going beyond training research to engineering psychology and individual differences.

Stolurow (1964) addressed learning principles in a taxonomy which reaffirmed the need for a systems language. The goal was to express all learning situations and learning data in one precise and consistent language. He developed a tentative taxonomy of learning tasks from data in the literature. Sets of task variables were isolated, defined and used to formulate hypotheses. As the hypotheses were tested, the structure and definition of the selected variables were revised. His systems-oriented learning paradigm consisted of four behavioral categories and a "performance standards" or criterion component for a proposed general training system. A limited study of the reliability was conducted and helped to clarify the meaning and application of the task categories. In this phase of the study eight psychologists were assigned a coding task. These subjects had all worked directly in training research or were familiar with the principles involved and were considered to be potential users of the taxonomy. The task consisted of two subtasks:

- to code task descriptions contained in the literature, and

- to decode a set of coded tasks which were prepared for the purpose of the study.

Through these coding and decoding trials, a final revision of categorical task definitions resulted. The proposed taxonomic model consisted of a provisional set of critical learning task characteristics represented in three major components in the systems analysis mode: input, output, and relationship. Task descriptions arising from relevant system-related characteristics specify the following about a learning situation: critical cue, response, and cue response relationships that will provide the performance standards for decisions about reinforcement. In support of his "functional classification" approach, Stolurow emphasizes the mutual exclusion capabilities of his categories, a criterion more typically met in the physical sciences than the behavioral. A possible use for the resultant taxonomy suggested by the author was the development of a manual providing guidance on training decisions.

Guilford's Structure of Intellect

Guilford (1967; Guilford and Hoepfner, 1971) developed a systematic schema of intellectual functions based on 20 years of factor analytic research known as the Aptitudes Research Project. He called this three-dimensional cube-like schema the structure of intellect model. Guilford attempted to simplify the configuration of trait relationships by organizing traits into three cognitive dimensions:

- Operations - the things a person can do; i.e., cognition, memory, divergent and convergent production and evaluation.

- Contents - the nature of the materials or information on which operations can be performed, i.e., figural, symbolic, semantic, and behavioral; and

- o Products - outcome or results of content processed by respondent. These products are classified into units, classes, relations, systems, transformations and implications.

Within these three dimensions of 5 x 4 x 6 categories, 120 cells emerge, each cell expected to contain at least one factor (ability). Each factor is described in terms of all three dimensions. Therefore, the model posits a maximum of 120 aptitudes, 98 of which were identified in the final report (Guilford and Hoepfner, 1971).

Meeker (1969) applied the structure of intellect model to classify items of the Stanford-Binet and Wechsler scales; however no similar application to actual work performance has been identified in the literature. "The structure of intellect model has been internally oriented making little or no contact with the real world of human work performance" (Dunnette, 1976 p. 480). The structure of intellect model has little use for understanding actual work performance since no empirical linkage has been established.

Berliner, Alliusi, and Chambers

Other general behavioral taxonomies can be briefly described. For example, Berliner et al. (1964) developed a three-tier task classification system using perceptual/psychomotor descriptions. As Siegel et al. (1980 p. 4) observe, this system "classifies tasks in terms of intervening human processes or functions as related to general work activities and specific behaviors or tasks". The initial level, Processes, describes the gross function (e.g., perceptual processes), whereas the next category, Activities, depicts a more detailed function (e.g., searching for and receiving information). The third category, Behaviors, involves task description (e.g., detects, inspects, observes, etc.). While this taxonomy provided a useful structure for detailing elements of task performance, it has limited utility for the development of the ARMPREP taxonomy. As Siegal et al. (1980) indicate, Berliner's system is predicated on behavior description, as detailed definitions of the processes are not provided. Also, Meister (1976) states that the taxonomic elements are not mutually exclusive.

Similar taxonomic systems have been developed by Alliusi (1967) and Chambers (1969). Alliusi isolated the following seven basic functions found in perceptual/psychomotor tasks: watchkeeping, sensory-perceptual, memory, communication, intellectual, perceptual-motor and procedural. Chambers omits Berliner's intermediate level (i.e., activities) and proceeds directly from the gross function to task behaviors. In Chambers's taxonomy, "superordinate functions are used only to cluster subordinate task categories, ensuring that only the detailed categories are much used (and are useful)" (Meister, 1976, p. 106). Satisfactory definitions of the categories are not given. These three taxonomic systems all have limited usefulness for ARMPREP for similar reasons. Siegel et al. (1980, p. 4) cogently describe these shortcomings in the following manner:

> Such taxonomic systems suggest the perceptual/psychomotor abilities required to perform tasks. However, the taxonomies are too broad or vague to identify the amount or type of perceptual/psychomotor ability required. Taken together, the three systems appear to be descriptive, nonrigorous, qualitative, and general types of taxonomies. They were subjectively developed and depend heavily on verbal descriptions, with somewhat overlapping functions and behaviors.

<u>Summary</u>

Figure F-1 summarizes the applicability of the major taxonomies reviewed in this section to the ARMPREP system. The matrix depicts application of the formal criteria to the particular taxonomies. The cell

Figure F-1
General Behavioral Taxonomies
Applicability to the ARMPREP System

FORMAL CRITERIA	Fleishman	Bloom	Gagne	Berliner	Cotterman	Guilford	Fitts	Stolurow
1. Behavior Focus	X			X		X		
2. Objective, Reliable				X		X		
3. Not Requiring Observation				X		X		
4. Discriminate Among MOS		X	X		X		X	X
5. Descriptive of Army MOS		X	X		X		X	X
6. Familiar Terms for SMES		X	X		X		X	X
7. Technically Defensible		X	X					

entries represent criteria which the taxonomies clearly fail to satisfy. These are not inherent shortcomings, but are limits on the applicability of these systems to ARMPREP. The entries are intended to be representative, rather than exhaustive, of the taxonomic systems' limitations.

TAXONOMIES AS PART OF METHODOLOGIES

Some taxonomies are part of methodologies for analyzing behavioral phenomena, including task characteristics, training situations, and job analysis, in military settings. This section examines representative taxonomic systems which serve these purposes.

R. B. Miller's Task Analysis

R. B. Miller generated taxonomies for task analysis. A task taxonomy classifies the behaviors involved in task performance. According to Miller (in Glaser, 1962) "It should be emphasized that task description is an instrument, not an end in itself" (p. 32). A task taxonomy is an information-getting and decision-making tool which must be evaluated on the basis of utilitarian criteria (Miller, 1971), and it should describe tasks to facilitate the identification and utilization of psychological information for making system design and personnel subsystem decisions. Miller's interest was the applicability of task taxonomies to the design of effective training. It appears worthwhile to explore the manner in which Miller employs task analytic procedures to promote training program design.

In describing tasks, Miller (1962) asserts that each task activity consists of the following:

- An indicator (source) on which the activity-relevant indication appears
- The indication or cue which calls for a response

- The control object to be activated
- An indication of response adequacy (i.e., feedback)

Miller's task analytic method provides a behavioral understanding of the task requirements. It emphasizes the human performance requirements, skills, and knowledges that need to be developed to perform a task. Miller identifies the following three functional requirements of tasks:

- The kinds and amount of output required
- Input variables, conditions, and situations
- The work objects which the operator is to use in transforming task inputs to task outputs

Miller's task analytic technique also derives gross specification of the training devices which are needed and the grouping of tasks for training. He begins with mission analysis and generates a task time chart that groups tasks as a function of time and kind (i.e., similarity of skill or equipment needed). The method includes a time diagram showing continuity among tasks and time-sharing considerations.

The tasks and subtasks are linked to types of trainers and stages of training. The subtasks are grouped according to training phases and devices on the basis of the analyst's expertise. As Smith (1965) observes, this method involves "a classification of training devices (on) a kind of habit or skill provided the trainee, rather than the subject matter taught" (p. 20). Within this matrix of trainer types and task lists, Miller considers the utility of familiarization trainers, instructed-response trainers, and automated skill. Miller (in Glaser, 1962, p. 57) summarizes the desired output of this process: "Ideally, a classification structure for tasks would be closely related to methodology and decision structure for the design of training." He has applied this procedure to the analysis of many tasks, including bookkeeping, inspection, starting engine and rotor, flight, hover and rescue, precautions and emergencies, and the operation of subsystems.

Miller's task analysis method has limited utility for the development of the ARMPREP taxonomy. Its applicability for manpower and personnel decisions has not been demonstrated. Wheaton et al. (1976) note that Miller's descriptions are not adequately defined and his procedures are not systematic. Smith (1965) maintains that Miller's method is largely intuitive in nature. These criticisms regarding the reliability of Miller's task analytic method lead to the conclusion that it is not transferable, to any large extent, to the ARMPREP taxonomic system.

Demaree's Learning Categories

Other behavioral researchers have developed task analytic methodologies. For example, Demaree (1961) has delineated the following four training functions, or categories of learning: learning of knowledge, skills and task components, whole-task performance, and integrated task performance. These training functions are crossed in matrix form with training device, training aid, etc. As Smith (1965) suggests, "from the point of view of task analysis methodology, the core of Demaree's method differs little from R. B. Miller" (p. 58). Here, a list of tasks is grouped first by stage and behavioral content, then it is coded by likely type of equipment. Willis (1961) also employs a task analytic method for prescribing training for skill acquisition. Willis's approach is unique in that it devotes attention to the derivation of learning principle categories. He has develped a matrix of 19 task or behavior categories and 13 learning principles. Tasks are placed in the categories according to their critical activities. The training design principles are organized into a training strategy. It should be noted that this step requires substantial expertise; again, reliability problems can plague this complex task analytic method.

Folley's Task Analysis

Folley (1964) developed a method for conducting task analysis in the training realm. His approach uses a system of interrelated definitions, constructs, and hypotheses linking task attributes to training requirements. This task analytic method (TAM), together with Van Alberti et al.'s (1964) training analysis procedure (TAP), comprises an overall training situation analysis (TSA). TAM has several stages that increase in detail. The user prepares task-time charts to show each task in a block, the operator, the time for event and task, coordination requirements, and adverse conditions. Then the user makes a functional task description to provide more detail as to typical time and maximum completion time. Each task is then analyzed using the following behavioral categories: procedure following, continuous perceptual-motor activity, monitoring, communicating, decision-making or problem-solving, and non-task-related activity. Finally, a behavioral details description identifies the psychological characteristics of task-related activities. Information from these TAM stages is translated into a set of functional training requirements on the basis of expert judgment.

The goal of TAP is to rank tasks as to the training benefit expected per dollar expended. The expected training benefit is defined by the anticipated improvement in performance and is obtained by estimating speed and accuracy for trained and untrained operators. Here, the ratio of improvement divided by cost is used to select tasks for training. While TAP offers explicit detail in these procedures, it typically encounters the following difficulties:

- Obtaining reliable information on untrained performance time and accuracy;
- impracticality of applying it to complex systems because of decision ambiguity;
- its possible insensitivity to task criticality, amount of training time required, use of part-task training, and the relationship of part-tasks to system performance.

Training situation analysis is especially strong in the task analytic method, which pinpoints critical information needed by the training analyst and requires less detailed raw task description than other methods.

Training Effectiveness and Cost Effectiveness Prediction

While the preceding task analytic approaches are closely related to training decisions, more recent methods focus more explicitly on the determination of training and cost effectiveness. An excellent illustration is Braby et al.'s (1975) Training Effectiveness and Cost Effectiveness Prediction (TECEP) model. In generating TECEP, Braby (1973) examined the task classification, learning and instructional media work by Ellis (1972), Gagne (1965), Miller (1967), Willis and Peterson (1961), and others. This technique represents the synthesis of several methods for choosing instructional media and has been designed to prescribe training programs during the conceptual phase of the system development and acquisition cycle.

TECEP, which begins with a list of training objectives, classifies these objectives according to the following twelve types of tasks:

1. Recalling Bodies of Knowledge
2. Using Verbal Information
3. Rule Learning and Using
4. Making Decisions
5. Detecting
6. Classifying
7. Identifying Symbols
8. Voice Communicating
9. Recalling Procedures-Positioning Movement
10. Steering and Guiding-Continuous Movement
11. Performing Gross Motor Skills
12. Attitude Learning

The training objective is categorized by comparing the task verb and description with the verbs and description of the task categories. A learning algorithm is provided for each task category. Defined by Braby et al. (1975 p. 14) it is "a step-by-step prescription for a student to follow learning any specific task in a class of learning tasks... a general sequence for use with all similar training objectives."

After generating these learning algorithms, it is possible to select alternative media systems to support the algorithms. In identifying instructional delivery systems, the primary TECEP criteria are that the system be capable of providing the essential stimulus characteristics, allow the trainee to respond to them and provide feedback and reinforcement. A stimulus-response-feedback analysis for the particular tasks is performed, with each task category having a chart for instructional delivery system selection. The chart represents the interface of potential media and special selection criteria. The user marks the criteria that must be satisfied by the media and the cells in the table where the media meet the criteria. The delivery systems must also meet the following criteria of practicality: marginal technical solutions, state-of-the-art, size of system, interface with existing program, time to produce system, budget cycle constraints, adoption of innovations, courseware development, high cost alternatives, learning style of trainees, and other constraints (e.g., command policy). In this manner, alternative delivery systems can be compared in terms of their capability for effective training on a given task set.

It should be mentioned that TECEP offers an alternative method for selecting media for special training needs. This method consists of these three steps:

- Refine the learning algorithm to suit the special need
- Select media characteristics from a list of 55 generic media characteristics
- Using a list of 89 media, identify all of the media which meet the special need, devise combinations of them, and reject those media which fail the practicality test

Braby et al. (1975) note, however, that this alternative method is highly creative and requires expert knowledge of the training content, algorithms, media, and special needs.

After determining suitable instructional systems for the delivery of training content, TECEP derives dollar costs for the alternative training delivery systems. Rather than a metric for effectiveness, it considers all systems that meet the training need, according to the learning principles stated in the learning algorithms and guidelines.

Position Analysis Questionnaire

Another well known task or job analytic method is the Position Analysis Questionnaire (PAQ) generated by McCormick et al. (1972). It consists of 189 job elements of a worker-oriented nature and is intended to characterize human behavior. McCormick identified the following six job divisions of behavioral areas, in which the 189 job elements are located: information input, mediation processes, work output, interpersonal activities, work situation and job context, and miscellaneous aspects. According to McCormick (in Dunnette, 1976), these six categories reflect the organization of human job behaviors. In other words, they represent the extent to which job behaviors tend to group themselves together in the world of work. Further, McCormick observes that these job elements vary in terms of their presence or absence and degree of importance across different jobs. During the last several years, McCormick and his associates have utilized the PAQ to describe over 500 different jobs. This factor analytic work has yielded the following job dimensions:

- o decision/communication/social
- o skilled activities
- o physical activites/related context conditions
- o equipment/vehicle operation
- o information processing activities

McCormick's job analytic research, unlike previously described training-related work, has been directed toward resolving manpower and personnel issues, such as recruitment and job placement. As such it possesses relevance for this project's purposes. However, the emphasis upon behavior description, rather than behavior requirements, limits its utility for the development of the ARMPREP taxonomy.

Libbey's Technical Information Structure

Occasionally, a taxonomy serves as a specific methodological tool. The best example of this taxonomic function is the generation of vocabulary lists to establish standard meanings for the elements of interest. In this lexicon approach, types of information are classified in terms of a hierarchical structure of information descriptions. Libbey (1971) developed a faceted classification procedure to support the identification of technical information problems and policies relating to Army, DoD, and other federal libraries and services. Each facet, or topic, was structured according to the most effective way of representing reality. Some facets were structured hierarchically, while others were structured with sub-facets or some combination of these principles. Libbey concluded that an important function of this classification scheme involves providing a common language for diverse and disparate individuals.

Summary

Figure F-2 summarizes the applicability of the taxonomies reviewed in this section for the ARMPREP system. Again, the cell entries are intended to be representative of the shortcomings of these systems in meeting the formal criteria for ARMPREP.

SPECIFIC TAXONOMIES

Many taxonomies are designed with a particular purpose in mind and in that situation are useful in an immediate and concrete sense. Meister (1976) states that "taxonomies of greatest use to the system development specialist are those that are most specific and descriptive of tasks as observed." There are many examples of specific taxonomies from the human

Figure F-2
Taxonomies as Part of Methodologies
Applicability to the ARMPREP System

SPECIFIC CRITERIA	R. B. Miller	Demaree	Willis	Folley	Braby	McCormick	Libbey
1. Behavior Focus						X	
2. Objective, Reliable	X	X	X	X	X		
3. Not Requiring Observation						X	
4. Discriminate Among MOS	X	X	X	X	X		X
5. Descriptive of Army MOS	X	X	X	X	X		X
6. Familiar Terms for SMEs	X	X	X	X	X		X
7. Technically Defensible							X

factors literature. Krumm and Farina (1962), using a content analytic methodology, derived a set of communication categories for a four-man aircraft crew. Siegel and Federman (1973) devised a complex communications taxonomy using factor analysis, and Siegel, Federman and Welsand (1980) developed a taxonomy of perceptual/psychomotor requirements for performance in 35 Air Force specialties.

Such specifically oriented taxonomies may be limited for application beyond their assigned purpose. Certain taxonomies are especially useful due to their applied orientations, even though they arise from highly diverse objectives.

Functional Job Analysis

Fine's (1972) Functional Job Analysis scheme, developed to standardize jobs, categorizes tasks according to their emphasis on the characteristic distinctions among people, data, and things. Task statement goals were devised to meet the criterion of communicating the task reliability, that is, the task statement should be highly congruent with the task performer's perception. Task statements should be similar to the task itself and compatible with all other task statements. "A task is an action or action sequence grouped through time and designed to contribute a specified end result to the accomplishment of an objective for which functional levels and orientation can be reliably assigned. The task action or action sequence may be primarily physical such as operating an electric typewriter; or primarily mental, such as analyzing data; and/or primarily interpersonal, such as consulting with another person" (Fine and Wiley, 1971). A consensus can be reached on task goals and qualifications necessary to attain those goals. A model sentence worksheet reduces the task to components based on the distinction of people/data/things and behavior/end results. These task statement components include: subject (worker), action verbs (performs), object of verb (to whom or what), phrase (upon what instructions), phrase (using what tools, equipment, work aids, etc.) and in order to (expected output). Standardized questions were then developed regarding the interaction of the components and their relation to organizational goals. These questions were used for testing reliability and validity of task statements. Fine (1971) explains a technique for writing task statements to improve reliability.

The systematic clustering of task statements into assignments has facilitated personnel decisions and resulted in predictable outcomes. Such results have implications for the use of Fine's methodology across a variety of manpower and personnel areas such as job restructuring, development of career ladders, and manpower utilization studies, to name a few.

Another specifically applied taxonomic system involves Ramsey-Klee's (1979) analysis of Navy enlisted occupational classifications. She gathered task inventory data for the following five Navy enlisted ratings; Aviation Boatswain's Mate (AB), Aviation Machinist's Mate (AA), Electronics Technician (ET), Torpedoman's Mate (TM), and Yeoman (YN). There were two purposes for examining these task data. First, it was necessary to define the taxonomy structure underlying the design of the Navy Occupational Task Analysis Program's (NOTAP) task inventory booklets. Second, this effort aided the development of alternative taxonomic structures which would extend the usefulness of the task inventory data and shorten the task inventories. Here, a reduction of time demand on operational units in terms of their administrative activities would result.

Ramsey-Klee's content analysis methodology began with an examination of over 2000 task statements in NOTAP. These statements were delineated into 21 categories at the first, gross level, and were further broken into 76 additional categories at the second, more specific level. This procedure was deemed useful for comparing Navy ratings, relating task analysis data to occupational standards, and systematically generating task statements. In addition, a clustering approach, which used job titles and determined cluster membership by the Group clustering program in CODAP (Comprehensive Occupational Data Analysis Programs), was applied to the same data. According to Ramsey-Klee (1979),

> This approach had its genesis in the notion that if the members of a cluster could be characterized by a single job title or by a homogeneous set of job titles, then one could conclude that job titles, although often cryptic and general, do have a common interpretation to the job incumbents who selected them. Conversely, if a particular job title is not concentrated in one of a few clusters, then one might conclude either that it is a heterogeneous job or that the job title is ambiguous and means different things to different people. This conclusion would cast suspicion on the usefulness of the job title (p. 33).

Ramsey-Klee reported that while some of the informal job titles requested in the inventories corresponded to well-defined clusters derived from task statements, other job titles did not appear to be universally understood. As a result, she suggested that the job title section be dropped from the task inventory booklets.

McKnight's Transportation Analysis

McKnight and Adams (1971, 1972) conducted a large project for the Department of Transportation which included:

- Development of a methodology to evaluate and analyze the criticality of driver behaviors, and

- o The development of driver education objectives and a national standard of evaluation for such programs

Our focus will be on the comprehensive methodology that was developed. Initially, to assume a comprehensive identification of driving behaviors, an analysis was conducted of the total highway transportation system including the driver, vehicle, roadway traffic and natural environmental conditions. From the perspective of each system component and the possibility posed by their various interactions, specific driving situations were identified as well as the appropriate operator response or response sequence. Groups of related behaviors were clustered together and comprised the tasks that would undergo further analysis, associating cues with driving responses. A large group of experts was convened representing every aspect of highway-related traffic safety for the purpose of evaluating the criticality of more than 1500 behaviors identified during analysis relating to safety and efficiency of the highway transportation system. From the resulting criticality indices and substantive information gained though a literature review, the driving behaviors were then incorporated into a set of driving task descriptions. The behaviors identified during the analysis of driving tasks varied considerably in their criticality to the safe and efficient operation of the highway traffic system. The importance of criticality as a dimension was due to the objective of an efficient driver education program in which it would be virtually impossible to include every possible traffic behavior. Yet it was important to identify those behaviors most critical to safe and efficient driver practices. From such a wide range of possible behaviors only such a broadly conceived systematic approach could produce the desired results. In addition to criticality data, the literature review provided information concerning a) characteristic levels as well as upper and lower limits of driver performance, and b) related knowledges and skills. Task descriptions which arose as a result of a thorough task analysis and criticality evaluation were included as part of the skill category, the last step of McKnight's analytic process. Along with knowledge they were used to support the development of driver education objectives which took place during a subsequent phase of the study. The process used can be summarized as follows:

1. Goals of the transportation system were determined.

2. From each goal, behavioral requirements were determined.

3. The scope of the systems analysis included the identification of those characteristics of the transportation system which impose behavioral requirements upon drivers in fulfilling two levels of goals, individual and system-level.

4. System characteristics, as generated from an extensive literature survey, were used to comprise a logically organized hierarchy. They combined and grouped characteristics within certain logical and well-defined categories.

5. From a list of more than 1000, system characteristics were identified. System characteristics spawned more than 1500 specific behaviors required in driving.

6. Behaviors were organized according to the situations giving rise to them. (The could have been orgainzed in a number of other ways; e.g., to reflect the inherent structure of driving behavior, the responses evoked, or according to mediating processes).

7. Behaviors were further categorized and grouped into tasks. In this context, a task is a group of related behaviors directed toward a specific outcome.

   "As with most systems of classification, individual entries often warranted inclusion under more than one category." In this study, behaviors were entered under that one task that seemed to characterize them best and cross-reference was made when tasks were related.

8. Behaviors were analyzed to reach the appropriate level of detail necessary to achieve project goals.

9. Behavior criticality was evaluated. For the purpose of instructional objectives, it would not be feasible to include the full range of behaviors involved in vehicle operation in a course for beginning drivers.

10. The task analysis and the criticality evaluation were used to develop a set of task descriptions oriented to the driving public (a highly diversified audience). These task descriptions would form the basis for deriving instructional material and could be used by SME's in rating and assessing behaviors on a variety of system dimensions.

McKnight and Adams's methodology used a multi-tiered task analysis focusing on behavior requirements addressed to the appropriate system level. The appropriate system level is determined according to the specific project goal and identified through a comprehensive analysis of behaviorally-relevant system characteristics including (1) driver characteristics, (2) vehicle characteristics, (3) roadway characteristics, (4) traffic characteristics, and (5) environmental conditions. These investigators were able to combine a detailed, well specified methodology with a behaviorally complex conceptual goal that resulted in a widely applied tool.

Comprehensive Occupational Data Analysis Program

From a personnel orientation, The Air Force's Comprehensive Occupational Data Analysis Program (Christal, 1974; Christal and Weismuller, 1976) is a highly interactive and efficient system of computer routines for organizing, analyzing and reporting occupational information. It is a sophisticated example of the use of cluster analysis for grouping jobs along a variety of dimensions. Though the use of Ward and Hook's hierarchical grouping procedure (Ward, 1963, Ward and Hook, 1963), an iterative clustering method, Air Force jobs are analyzed according to the incumbent's task inventory response. This method has been used to form clerical job families on the basis of both worker-oriented activities and attribute requirements (Brush and Owens, 1979), and develop families of exempt occupations in a power utility firm on the basis of a job-oriented checklist (Krzystofia et al. 1979). The original CODAP package has been augmented to fill in gaps for addressing new problem areas (Christal and Weismuller, 1976). For instance, the researchers demonstrate how the more recent programs can be used to develop and apply an equation which assigns training priorities to tasks in an occupational area based upon consideration of relevant task factor information.

Summary

Figure F-3 summarizes the applicability of the taxonomies reviewed in this section for the ARMPREP system. As with the previous sections, cell entries are intended to represent the shortcomings of these systems in meeting the formal criteria for ARMPREP.

Figure F-3
Specifically Applied Taxonomies
Applicability to the ARMPREP System

FORMAL CRITERIA	Fine	McKnight	Ramsey-Klee	AR 611-201	Christal
1. Behavior Focus					
2. Objective, Reliable					
3. Not Requiring Observation					
4. Discriminate Among MOS	X	X	X		X
5. Descriptive of Army MOS	X	X	X		X
6. Familiar Terms for SMEs	X	X	X		X
7. Technically Defensible	X	X			

CONCLUSIONS

As the literature review indicates, many taxonomies have been developed and applied in the behavioral sciences. These systems have addressed several psychological concerns, including cognitive processes, learning principles, and human abilities. Furthermore, taxonomic systems have been used as part of a methodology for conducting task, training, and cost analyses. Also, these taxonomies have been applied to solving specific problems in military (e.g., Ramsey-Klee, 1979; Christal, 1974) and non-military (e.g., McKnight, 1972; Fine et al., 1974) settings. Unfortunately, these classification systems fail to meet the specific criteria for the development of the ARMPREP taxonomy. Specifically, most of these taxonomies do not fulfill the following requirements:

- Description of Army MOS - most taxonomies are delineated at a too molecular content level
- Technical Defensibility - many systems are too general in nature to be technically adequate
- Objective - many taxonomic systems rely upon subjective judgments and possess limited reliability

In addition, many taxonomies focus upon behavior description or ability requirements, rather than emphasizing behavior requirements. In this regard, some systems depend upon behavior observation for the determination of task descriptive data. Clearly, these formal criteria for the development of the ARMPREP taxonomy prevent the direct transfer of any existing system to ARMPREP.

While no extant taxonomy is wholly applicable to ARMPREP, some can assist in the development of the Army MOS-related taxonomy (e.g., Fleishman, 1967). Many taxonomies offer a useful structure for considering task performance. Further, those which focus on behavior requirements (e.g., Bloom, 1956; Gagne, 1962) direct attention to intended versus actual behaviors, and they may help to make personnel decisions based upon system requirements without behavior observation. While several taxonomies are oriented toward training program design and evaluation, others are specifically directed towards the manpower and personnel areas (e.g., McCormick et al., 1972). The research on job clusters or job families can be applied to an Army MOS-related taxonomy. Finally, several task-oriented taxonomic systems (e.g. Braby et al., 1975; Folley, 1964; Willis, 1961; and Miller, 1962) demonstrate that a classification system can serve as a methodological tool. These potential contributions are quite general in terms of their guidance without actually providing specific elements to the ARMPREP taxonomy. As Dunnette (1976, pp. 514, 516) observes,

> So far, no one has derived a behavioral taxonomy midway between the world of work and the world of human attributes measured via standardized tests and inventories. Such a taxonomy could serve a useful purpose as a common reference frame for evaluating and assigning both the important behavioral elements necessary for adequately performing different jobs and the reasonable human attributes shown to be necessary for carrying them out (p. 514, 516).

A large discrepancy exists between the taxonomic requirements and available classification systems; thus, it is necessary to transcend these systems, adapting their strengths and overcoming their weaknesses using supplemental materials. The ARMPREP taxonomy must derive behavioral requirements from task descriptive data to make manpower and personnel decisions for emerging weapon systems. Based upon the literature review of taxonomic systems, it appears that AR 611-201 best satisfies the formal criteria for the generation of the ARMPREP taxonomy. As a result, this taxonomic system will be developed from the MOS descriptions contained in AR 611-201. While AR 611-201 is not an explicitly stated taxonomy, the MOS information it contains forms an implicit, underlying taxonomic base and will be extracted and made explicit in developing the ARMPREP taxonomy. The following sections provide a detailed description of the methodology employed for the generation of the ARMPREP taxonomy from the MOS-related material contained in AR 611-201.

REFERENCES

Aagard, J. A. and Braby, R. Learning guidelines and algorithms for types of training objectives (TAEG Report No. 23). Orlando, FL.: Training Analysis and Evaluation Group, March 1976.

Alluisi, E. A. Methodology in the use of synthetic tasks to assess complex performance. Human Factors, 1967, 9, 375-384.

Altman, I. Aspects of the criterion problem in small group research. II. The analysis of group tasks. Acta Psychologica, 1966, 25, 199-221.

Altman, I. Choicepoints in the classification of scientific knowledge. In B. P. Indek and F. K. Berrien (Eds.), People, Groups and Organizations. New York: Columbia University Teacher's College Press, 1968.

Annett, J., & Duncan, K. D. Task analysis and training design. Occupational Psycoholgy, 1967, 41, 211-22.

Auld, F. and Murray, E. J. Content analysis studies of psychotherapy. Psychological Bulletin, 1955, 52, 377-395.

Bales, R. F. Interaction process analysis: A method for the study of small groups. Cambridge, Massachusetts: Addison-Wesley, 1950.

Berelson, B. Content analysis in communications research. Glencoe, Illinois: Free Press, 1952.

Bergen, F. H. and Weiss, D. J. Cluster analysis and counseling research. Journal of Counseling Psychology, 1971, 18, 503-591.

Berliner, D. C., Angell, D., and Shearer, J. Behaviors, measures, and instruments for performance evaluation in simulated environments. Paper presented at Symposium and workshop on the Quantification of Human Performance, Albuquerque, New Mexico, August 17-19, 1964.

Bloom, B. S. (ed.). Taxonomy of educational objectives. The classification of educational goals, Handbook 1: Cognitive domain. New York: Longmans, Green, and Co., Inc., 1956.

Borgatta, E. F. and Cottrell, L. S. On the classification of groups. Sociometry, 1955, 18, 665-678.

Borgatta, E. F. and Meyer, H. J. On the dimensions of group behavior. Sociometry, 1956, 19, 223-240.

Braby, R., Henry, J. M., Parris, W. F., Jr. and Swope, W. M. A technique for choosing cost-effective instructional delivery systems (TAEG Rep. #16). Orlando, FL.: Training Analysis and Evaluation Group, April 1975.

Brush, D. H. and Owens, W. A. Implementation and evaluation of an assessment classification model for manpower utilization. Personnel Psychology, 1979, 32, 369-383.

Carter, L. F. Recording and evaluating the performance of individuals as members of small groups. Personnel Psychology, 1954, 7, 477-484.

Cattell, R. B. Concepts and methods in the measurement of group syntality. Psychological Review, 1948, 55, 48-63.

Cattell, R. B. and Stice, G. P. The psychodynamics of small groups. Urbana, Illinois: University of Illinois, 1953.

Cattell, R. B. Abilities: Their structure, growth, and action. Boston: Houghton Mifflin, 1971.

Chambers, A. N. Development of a taxonomy of human performance: A heuristic model for the development of classification systems (AIR Tech. Rep. 726-TR4A). Silver Spring, MD: American Institutes for Research, July 1969.

Chiles, W. D. Methodology in the assessment of complex performance: Disscussion and conclusions. Human Factors, 1967, 9, 385-392.

Christal, R. E. The United States Air Force occupational research project. Lackland AFB, Texas. Air Force Human Resources Laboratory, 1974.

Christal, R. E. and Weissmuller, J. J. New CODAP programs for analyzing task factor information (AFHRL-TR-76-3). San Antonio, Texas: Air Force Human Resources Laboratory, Brooks AFB, May 1976.

Christensen, J. M. and Mills, R. G. What does the operator do in complex systems? Human Factors, 1967, 9, 329-340.

Colson, K. R., Freeman, F. S., Mathews, L. P., and Stettler, J. A. Development of an informational taxonomy of visual displays for Army tactical data systems (Research memo 74-4.). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences, February 1974.

Cotterman, T. E. Task classification: an approach to partially ordering information on human learning (WADC TN58-374). Wright-Patterson Air Force Base, Ohio, January 1959.

Demaree, R. G. Development of training equipment planning information (ASD Tech. Rep. 61-533), Air Force, October 1961.

Denisi, A. S. and McCormick, E. J. The cluster analysis of jobs based on data from the PAQ (Rep. No. 7). West Lafayette, Indiana. Purdue University, September 1974.

Deutsch, K. W. Communication codes for organizing information. Behavioral Science, 1966, 11, 1-18.

REFERENCES (Continued)

Dunnette, M. D., Aptitudes, abilities and skills. In Dunnette, M. D. Handbook of industrial and organizational psychology. Chicago: Rand McNally, 1976.

Ekstrom, R. B., French, Harmon, and Dermen. Manual for Kit of Factors-Referenced Cognitive Tests. Princeton, New Jersey: Educational Testing Service, 1976

Ellis, H. C. Fundamentals of human learning and cognition. Dubuque, Iowa: William C. Brown Co., 1972.

Farina, A. J. Development of a taxonomy of human performance: a review of descriptive schemes for human task behavior (AIR Tech. Rep. 726-TR2). Silver Spring, MD.: American Institutes for Research, 1969.

Farina, A. J., Jr. and Wheaton, G. R. Development of a taxonomy of human performance: The task characteristics approach to performance prediction. JSAS catalog of selected documents in psychology, 1973, 3, 26-27.

Farina, A. J. and Wheaton, G. R. Development of a taxonomy of human performance: the task-characteristics approach to performance prediction (AIR Tech. Rep. 726-TR7). Silver Spring, MD.: American Institutes for Research, 1971.

Fine, S., Holt, A., and Hutchinson, M. Functional job analysis: How to standardize task statements. Kalamazoo, Michigan: The W. E. Upjohn Institute for Employment Research, October, 1974.

Fine, S. A. and Wiley, W. W. An introduction to functional job analysis: A scaling of selected jobs from the social welfare field. Methods for Manpower Analysis, 4, September, 1971.

Fitts, P. M. Factors in complex skill training. In R. Glaser (Ed.), Training research and education. Pittsburgh, PA.: University of Pittsburgh Press, 1962.

Fleishman, E. A. Development of a behavior taxonomy for describing human tasks: A correlation-experimental approach. Journal of Applied Psychology, 1967, 51, 1-10.

Fleishman, E. A. On the relation between abilities, learning, and human performance. American Psychologist, 1972, 27, 1017-1032.

Fleishman, Edwin A. Toward a taxonomy of human performance. American Psychologist, December 1975, 1127-1149.

Fleishman, E. A. Systems for describing human tasks. American Psychologist, 1982, 37, 821-834.

Folley, J. D., Jr. Development of an improved method of task analysis and beginnings of a theory of training. (NAVTRADEVCEN 1218-1), U. S. Naval Training Device Center, Port Washington, New York, June 1964.

Frank, P. Philosophy of science. Englewood Cliffs, New Jersey: Prentice-Hall, 1957.

Gagne, R. M. (Ed.). Psychological principles in system development. New York: Holt, Rinehart, and Winston, 1962.

Gagne, R. M. The conditions of learning. New York: Holt, Rinehart and Winston, Inc., 1965.

Glaser, R. (Ed.). Training research and education. Pittsburgh: University of Pittsburgh Press, 1962.

Guilford, J. P. Nature of human intelligence, New York: McGraw Hill, 1967.

Guilford, J. P. and Hoepfner, R. The analysis of intelligence. New York: McGraw Hill, 1971.

Harrow, A. J. A taxonomy of the psychomotor domain. New York: David McKay, 1972.

Hays, R. T. Training simulator fidelity guidance: The iterative data base approach (Technical Report 545). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences, September 1981.

Hemphill, J. K. Group dimensions: A manual for their measurement. Columbus, Ohio: Ohio State University, 1956.

Hemphill, J. K. and Westie, C. M. The measurement of group dimensions. Journal of Psychology, 1950, 29, 325-342.

Kaplan, A. The conduct of inquiry: Methodology for behavioral science. San Francisco: Chandler, 1964.

Klein, F. A. Phenomenological approach to training (AFHRL Technical Report 77-42). Wright-Patterson AFB, Ohio: Air Force Human Resources Laboratory, August 1977.

Krathwohl, D. R., Bloom, B. S., and Masie, B. B. Taxonomy of educational objectives. The classification of education goals. Handbook II: Affective domain. New York: David McKay Co., 1964.

Krumm, R. C. and Farina, A. J. Effectiveness of integrated flight simulator training in promoting B-52 crew coordination (Report AMRL-TR-62-1.) Aerospace Medical Research Laboratories, Wright Patterson AFB, Ohio, February, 1962.

Krzystofiak, F., Newman, J. M. and Anderson, G. A quantified approach to measurement of job content: Procedures and payoffs. Personnel Psychology, 1979, 32, 341-357.

Levine, J. M. and Teichner, W. H. Development of a taxonomy of human performance: an information-theoretic approach (AIR Tech. Rep. 726-TR9). Silver Spring, MD.: American Institutes for Research, 1971.

Libbey, M. A. A data base of research affecting military technical information services. Bloomington, Indiana: Indiana University, December 1971.

Mallamad, S. M., Levine, J. M., and Fleishman, E. A., Identifying Ability Requirements by Decision Flow Diagrams. Human Factors, 1980, 22, 57-68.

Mann, M. Introduction to cataloging and classification of books. Chicago, Illinois: American Library Association, 1943.

Marsden, G. Content analysis studies of therapeutic interviews: 1954 to 1964. Psychological Bulletin, 1965, 63, (5), 298-321.

Mathis, B. A. Stability analysis of term similarities for information classification theory. Columbus, Ohio: Ohio State University, 1970.

McCormick, E. J., Jeanneret, P. R., and Mecham, R. C. A study of job characteristics and job dimensions as based on the position analylsis questionnaire (PAQ). Journal of Applied Psychology, 1972, 56, 347-368.

McGrath, J. E. and Altman, I. Small group research: Synthesis and critique of the field. New York: Holt, Rinehart, and Winston, 1966.

McKnight, J. A. and Adams, B. B. The development of driver education objectives through an analysis of the driving task (HumRRO Professional Paper p. 4-71). Alexandria, VA: Human Resources Research Organization, April 1971.

McKnight, J. A. and Adams, B. B. Driver education task analysis: task analysis methods (HumRRO Technical Report 72-13). Alexandria, VA: Human Resources Research Organization, April 1972.

Mecham, R. C. and McCormick, E. J. The rated attribute requirements of job elements in the position analysis questionnaire. Layfette, Indiana: Purdue University, 1969.

Meeker, M. N. The structure of intellect: Its interpretation and uses. Columbus, Ohio: Charles E. Merrill, 1969.

Meister, D. Behavioral foundations of system development. New York: John Wiley and Sons, 1976.

Miller, R. B. Task description and analysis. In R. M. Gagne (Ed.) Psychological principles in system development. New York: Holt, Rinehart, and Winston, 1962.

Miller, R. B. Task taxonomy: Science or technology. Ergonomics, 1967, 10, 167-176.

Miller, R. B. Development of a taxonomy of human performance: Design of a systems task vocabulary (AIR Tech. Rep. 726-TR11). Silver Spring, MD.: American Institutes for Research, 1971.

Nadler, L. B. Navy team readiness assessment. Unpublished paper. Washington, D. C.: Litton Mellonics System Development, February 1982.

Nadler, L. B. and Berger, L. E. A classification system for Navy teams. Arlington, VA: Litton Mellonics System Development, September 1981.

Naylor, J. C. and Dickinson, T. L., Task structure, work structure, and team performance. Journal of Applied Psychology, 1969, 53 (3), 167-177.

Pearlman, K. Job families: A review and discussion of their implications for personnel selection. Psychological Bulletin, 1980, 87 (1), 1-28.

Pool, I. (Ed.). Trends in content analysis. Urbana, Illinois: University of Illinois Press, 1959.

Powers, T. P. Selecting presentation modes according to personnel characteristics and the nature of job tasks - Part I. Job Tasks. Baltimore, MD: University of Maryland, Baltimore County, January 1977.

Ramsey-Klee, D. M. Taxonomic approaches to enlisted occupational classification. Vol. 1 (NPRDC-TR-80-7). Malibu, CA: R-K Research and System Design, December 1979.

Ramsey-Klee, D. M. Taxonomic approaches to enlisted occupational classification. Vol. 2 (NPRDC-TR-80-7). Malibu, CA: R-K Research and System Design, December 1979.

Ramsey-Klee, D. M. and Richman, V. Cross validation and generalization of a content analysis of the narrative sections of Navy performance evaluations for senior enlisted personnel. Malibu, CA: R-K Research and System Design, April 1973.

Ramsey-Klee, D. M. and Richman, V. Further investigations of content analytic techniques for extracting the differentiating information contained in the narrative sections of performance evaluations for Navy enlisted personnel. Malibu, CA: R-K Research and System Design, October 1975.

Rossmeissl, P. G., Tillman, B. W., and Rigg, K. E., Job Assessments of Software System (JASS) for Analysis of Weapon Systems Personnel Requirements - User's Guide. Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences, October 1982b.

Rossmeissl, P. G., Tillman, B. W., Rigg, K. E., and Best, P. R., Job Assessment Software System (JASS) for Analysis of Weapon Systems Personnel Requirements: Technical Report, Alexandria, Virginia; U.S. Army Research Institute for the Behavior and Social Sciences, October 1982a.

Shaw, M. E. and Costanzo, P. Theories of social psychology. New York: McGraw-Hill Book Company, 1970.

Siegel, A. I. and Federman, P. J. Communication content training as an ingredient in effective team performance. Ergonomics, 1973, 16, 403-416.

Siegel, A. I. and Federman, P. J. and Welsand, E. H. Perceptual/psychomotor requirements basic to performance in 35 Air Force specialties (Report AFHRL-TR-80-26) Brooks Air Force Base, Texas: Air Force Human Resources Laboratories, December, 1980.

Silverman, J. New techniques in task analysis. (SRM-68-12). San Diego, CA: U. S. Naval Personnel Research Activity, November 1967.

Smith, B. J. Task analysis methods compared for application to training equipment development (NAVTRADEVCEN 1218-5). Orlando, FL: U.S. Naval Training and Development Center, 1965.

Sneath, P. H. A. The application of computers to taxonomy. The Journal of General Microbiology, 1957, 17, 201-226.

Sneath, P. H. A. and Sokal, R. R. Numerical taxonomy: The principles and practice of numerical classification. San Francisco, CA: W. H. Freeman and Co., 1963.

Sorenson, J. R. Task demands, group interaction and group performance. Sociometry, 1971, 34, (4), 483-495.

Stogdill, R. M. Individual behavior and group achievement. New York: Oxford University Press, 1959.

Stolurow, L. M. A taxonomy of learning task characteristics (AMRL-TDR-64-2). Wright-Patterson Air Force Base, Ohio: Aerospace Medical Research Laboratories, January, 1964.

Teichner, W. H. and Whitehead, J. Development of a taxonomy of human performance: Evaluation of a task classification system for generalizing research findings from a data base (Technical Report No. 8). Silver Spring, MD. American Institutes for Research, April 1971.

Theologus, G. C. Development of a taxonomy of human performance: A review of biological taxonomy and classification (Technical Report No. 3). Silver Spring Maryland: American Institutes for Research, December, 1969.

Theologus, G. C. and Fleishman, E. A. Development of a taxonomy of human performance: Validation study of ability scales for classifying human tasks. (Technical Report No. 10). Washington, DC: American Institutes for Research, February 1971.

Theologus, G. C., Romashko, T. and Fleishman, E. A. Development of a taxonomy of human performance: A feasibility study of ability dimensions for classifying human tasks (Technical Report No. 5). Silver Spring, MD: American Institutes for Research, January, 1970.

Thurstone, L. L. A factor analysis study of perception. Psychometric Monograph, No. 4, 1944.

Tryon, R. C. and Bailey, D. G. Cluster analysis. New York: McGraw-Hill, 1970.

Van Alberti, C. E., Jeanthea, G. G., Gorby, J. T., and Parrish, J. A. Training Analysis Procedure (TAP), Volume II. Handbook for application. Darien, Connecticut: Dunlap and Associates, Inc., 1964.

Ward, J. H. Hierarchical grouping to optimize an objective function. Journal of the American Statistical Association, 1963, 58, 236-244.

Ward, J. H. and Hook, M. E. Application of an hierarchical grouping procedure to a problem of grouping profiles. Educational and Psychological Measurement, 1963, 23, 69-81.

Wheaton, G. W. Development of a taxonomy of human performance: A review of classificatory systems relating to tasks and performance (AIR Tech. Rep. 726-TR-1). Silver Spring, Maryland: American Institutes for Research, 1968.

Wheaton, G. W., Eisner, E. J., Mirabella, A., and Fleishman, E. A. Ability requirements as a function of changes in the characteristics of an auditory signal identification task. Journal of Applied Psychology, 1976, 6, 663-767.

Wheaton, G. W. and Mirabella, A. Effects of task index variations on training effectiveness criteria. Orlando, FL: Naval Training Equipment Center, 1972.

Willis, M. P. Deriving training device implications from learning theory principles (NAVTRADEVSEN 784-1). Orlando, FL: U.S. Naval Training Development Center, July 1961.

REFERENCES (Continued)

Willis, M. P. and Peterson, R. O. Deriving training device implications from learning theory principles. Volume II: Methodology. Port Washington, New York: U. S. Naval Training Device Center, 1961.

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